JOURNAL

OF THE

ARNOLD ARBORETUM

VOL. XXVI APRIL, 1945 NUMBER 2

# A TAXONOMIC REVIEW OF TROCHODENDRON AND TETRACENTRON

A. C. SMITH

*With one text-figure*

## INTRODUCTION

IN CONTINUATION of the studies of certain woody families of Ranales undertaken by Prof. Bailey, Dr. Nast, and the writer, and published in recent volumes of this Journal, we propose next to consider a group of eastern Asiatic genera which have, from time to time, been associated with one another in the same family, subfamily, or tribe. These genera are *Trochodendron* Sieb. & Zucc. (1838), *Euptelea* Sieb. & Zucc. (1841), *Cercidiphyllum* Sieb. & Zucc. (1846), *Tetracentron* Oliv. (1889), and *Eucommia* Oliv. (1890). That these genera, all of which are small and some of which are monotypic, have aroused a high degree of interest among taxonomists, phylogenists, morphologists, anatomists, and horticulturists during the last century is demonstrated by the fact that we have examined, in connection with our studies, more than 250 separate papers discussing one or more of them. Many of these papers are floristic or horticultural notes, others are standard works of a taxonomic nature, but not a few are detailed morphological and anatomical studies. Our examination of past work has been as exhaustive as possible, in order that we might become familiar with the many and often conflicting opinions concerning the phylogeny and morphology of the genera concerned. These opinions have ranged from that of van Tieghem (26), who places each of the five genera in a separate family, to those of Finet and Gagnepain (5), who join all the genera in a single tribe of the Magnoliaceae, Oliver (23), who joins them all in the Trochodendraceae, and Hallier (8), who places them all in the Hamamelidaceae. Between these extreme views are to be found all shades of opinion, and the classification of these five genera remains an enigma to most students.

As a result of our study of ample material of the groups in question — material doubtless far exceeding in quantity and quality any available to

past students, largely because of the extensive Asiatic herbarium of the Arnold Arboretum — we are inclined to support the view of van Tieghem and to erect separate families for the five genera. This course may appear radical to conservative taxonomists, who are perhaps inclined to overlook the fact that, in dealing with very ancient and primitive groups such as the Ranales, a sound classification cannot be attained by the use of traditional comprehensive family limits. Our criteria for family delimitation in the Ranales, we believe, are as sound and conservative as those in current usage by students of other orders; that the application of these criteria results in the establishment of numerous small, or even monotypic, families in the Ranales reflects upon the extraordinary diversity and great age of the group, and not upon an exceptionally radical viewpoint on our part. At any rate, in placing *Trochodendron, Euptelea, Cercidiphyllum, Tetracentron,* and *Eucommia* in separate families we are proposing nothing new. Such recent phylogenists as Hutchinson (19), Wettstein (30), and Diels (4) have arranged the genera in question in either three or four families. Our principal disagreement with these students is the separation of *Tetracentron* from the Magnoliaceae and of *Euptelea* from the Trochodendraceae (the latter course also proposed by Wettstein). As a matter of fact, *Cercidiphyllum* and *Eucommia,* according to many modern treatments, are to be removed from the Ranales altogether and placed as relatives of the Hamamelidaceae and Urticaceae respectively.

The present paper is planned to redescribe the monotypic genera *Trochodendron* and *Tetracentron,* to give reasonably full citations to the literature pertaining to these genera, to list the specimens available in the larger American herbaria, and briefly to discuss the inter-relationships of the two groups. In the following paper in this Journal, Prof. Bailey and Dr. Nast initiate a series designed to discuss the morphological and anatomical details of *Trochodendron* and *Tetracentron.* In the course of this study we have fortunately been able to examine material from the following herbaria, hereafter designated by the parenthetical letters: Arnold Arboretum (A), Chicago Natural History Museum (Ch), Gray Herbarium (GH), Missouri Botanical Garden (M), New York Botanical Garden (NY), University of California (UC), and U. S. National Herbarium (US). The privilege of borrowing this material is greatly appreciated.

Perhaps the best way to outline the principal studies on the five genera mentioned above is to give a brief chronological sketch of past work; those treatments which appear to be of especial importance in an understanding of the groups are discussed in the following paragraphs.

## HISTORICAL SKETCH

Until the nineteenth century was well advanced, Japan remained an unknown land to European botanists. For that reason many of the conspicuous and widely cultivated trees of that country received no botanical names until the publication of the important Flora Japonica by Siebold and Zuccarini (1826–1870). In this publication, in 1838, *Trochodendron aralioides* was described and well illustrated, being placed in the "Winter-

aneae" of R. Brown. In 1840 Junghuhn (in Tijdschr. Nat. Gesch. Phys. 7: 308) independently described *Gymnanthus paradoxus* as a Japanese plant of the Magnoliaceae, related to *Illicium.* The identity of his plant with *Trochodendron aralioides,* apparently first pointed out by Endlicher (Gen. Pl. Suppl. 2: 73. 1842), has been obvious to all subsequent students.

*Euptelea* was founded in 1841 by Siebold and Zuccarini (Fl. Jap. 1: 133), with one species, *E. polyandra,* as a new genus of the Ulmaceae. *Cercidiphyllum,* proposed without a specific epithet by the same authors in 1846 (in Abh. Bayer. Akad. Wiss. Math. Phys. Cl. 4[3]: 238), was not related by them, their specimen having been in fruit only. The specific epithet *japonicum* was added to *Cercidiphyllum,* and accredited to Siebold and Zuccarini, by Hoffmann and Schultes in 1852 (in Jour. Asiatique IV. 20: 282).

The nomenclators of the period preceding 1860 — namely Endlicher, Steudel, Walpers, Meisner, Dietrich, and Lindley — agreed in referring *Trochodendron* to the Magnoliaceae as a relative of *Illicium,* in placing *Euptelea* in the Ulmaceae, and in ignoring *Cercidiphyllum.*

In 1858 Miers (22) published a study of the Winteraceae, pointing out that *Trochodendron* is not a relative of the group but more nearly approaches the Ternstroemiaceae — a suggestion which was not taken seriously by subsequent students. Bentham and Hooker, in their Genera Plantarum (1: 17. 1862), unwisely stated that *Trochodendron* is ". . . Araliacea anomala ovario subsupero," for which they were rebuked by Seemann in his revision of the Hederaceae (in Jour. Bot. 2: 238. 1864). For *Trochodendron* and *Euptelea,* Seemann proposed the new "order" Trochodendreae, relating it to the Wintereae, Ranunculaceae, and Magnoliaceae. Seemann was thus the first to suggest the isolated nature of *Trochodendron,* although he is not usually recognized as the author of the family Trochodendraceae because of his spelling of the name.

Hooker and Thomson (16), in 1864, in a short but important study of *Euptelea,* agreed with Seemann in removing it from the Ulmaceae. They concluded to place the genus in the Magnoliaceae, "section" Wintereae, noting its highly anomalous nature and stating that it might possibly represent a distinct family. Hooker and Thomson first called attention to the existence of this group of plants outside of Japan, by proposing the new species *Euptelea pleiosperma* from northeastern India.

Also in 1864, Eichler (2) published a very important anatomical study of *Drimys* and *Trochodendron,* concluding that the latter genus belongs in the vicinity of the Winteraceae. The following year Eichler (3) emphasized his conclusions and his agreement with Seemann in a supplementary paper.

Bentham and Hooker profited from the work of Seemann and Eichler, and in a supplement to the first volume of Genera Plantarum (1867) they erected the tribe Trochodendreae in the Magnoliaceae, for *Trochodendron* and *Euptelea.* The same position was indicated for the two genera by Baillon (Hist. Pl. 1: 191. 1868–69), under the name Magnoliaceae IV. [series?] "Eupteleeae."

The genus *Cercidiphyllum,* after a long period of neglect, was again brought into the discussion by Baillon (in Adansonia 10: 132. 1871) in connection with his notes on the Hamamelidaceae; his noncommital account also suggested that the genus is related to the Saxifragaceae, series "Cunoniées." Maximowicz (in Mél. Biol. 8: 142. 1872) was the first to associate *Cercidiphyllum* with *Trochodendron* and *Euptelea* in the Magnoliaceae. Maximowicz also proposed a second species of *Cercidiphyllum* and divided *Trochodendron aralioides* into two varieties, one based upon his own inadequately published *T. longifolium.* Franchet and Savatier, in 1873, in their enumeration of Japanese plants, followed Maximowicz in referring all three genera to the Magnoliaceae.

The family Trochodendraceae, in its modern spelling, was proposed by Prantl in 1888 (24) to include *Cercidiphyllum, Euptelea,* and *Trochodendron;* in a supplement to the same work in 1891 Prantl further extended the family to include *Tetracentron.* The last genus was described by Oliver in 1889 (in Hook. Ic. Pl. 19: *pl. 1892*), on the basis of Henry's collections from Hupeh, and was placed in the Magnoliaceae, tribe Trochodendreae. In the following year, Oliver described the monotypic *Eucommia* (in Hook. Ic. Pl. 20: *pl. 1950.* 1890), also based on Henry's plants from Hupeh, without referring it to a family.

Toward the end of the nineteenth century, some of the genera under discussion were introduced into Europe and North America for cultivation, especially *Cercidiphyllum,* a striking tree which is now to be seen in many parks and botanical gardens. *Eucommia* attracted attention for the gutta-percha content of its bark. During the following years the remaining genera were also brought into cultivation to a more limited extent, largely through the efforts of Sargent at the Arnold Arboretum.

By far the most important morphological discussion of these plants up to that time was Harms' study of the Trochodendraceae in 1897 (10). Harms pointed out that the wood of *Tetracentron* is vesselless, like that of *Trochodendron* and *Drimys.* He retained *Tetracentron* in the Magnoliaceae with the explanation that this family, which he interpreted to include such an anomalous genus as *Drimys,* is not unduly expanded by the inclusion of *Tetracentron.* The remaining four genera were placed by Harms in the Trochodendraceae — the Eupteleoideae for *Cercidiphyllum, Euptelea,* and *Eucommia,* and the Trochodendroideae for *Trochodendron.* While one cannot agree with Harms' disposal of these genera, it should be pointed out that his subsequent studies caused him to modify his opinions; his morphological and anatomical work on *Trochodendron* and its "allies" is of the highest quality and his several papers are indispensable for a knowledge of these plants.

A work of even greater import was van Tieghem's study of the "Homoxylées," published in 1900 (26). It is unfortunate that van Tieghem's presentation was so untraditional from a taxonomic point of view, for had his conclusions been presented in a more orthodox manner his treatment surely would have received the attention it merited from his contemporaries. Rec-

ognizing that the three groups typified by *Trochodendron, Tetracentron,* and *Drimys* stand apart from all other dicotyledons in their vesselless wood, van Tieghem proposed for them the subclass Homoxylées, as opposed to the Hétéroxylées, including all the other dicotyledons. His Homoxylées are divided into three families, the Trochodendracées, Tetracentracées, and Drimytacées (Winteraceae of other authors). With some emphasis, van Tieghem pointed out that these families could not be associated with the genera *Eucommia, Cercidiphyllum,* and *Euptelea,* for which he proposed the family names Eucommiacées, Cercidiphyllacées, and Euptéléacées respectively. While van Tieghem's work on these genera leaves much to be desired, his conclusions appear to be far sounder than those of his contemporaries. An amusing commentary of van Tieghem's perhaps deserves to be quoted in full (26: 261): "Il [le petit groupe des Homoxylées] se compose, pour le moment, des trois genres Trochodendre, Drimyte et Tétracentre. Malgré leur caractére si remarquable, qu'on vient de rappeler, ces trois genres ont été, et sont encore aujourd'hui classés tous purement et simplement dans la famille des Magnoliacées, ou dans son voisinage immédiat. Quand on étudie cette famille, on se borne à dire à leur sujet: 'Chose curieuse, il y a tel et tel genre de Magnoliacées, où le bois secondaire est homogène, différent de celui de toutes les autres Dicotylédones et semblable à celui de la presque totalité des Gymnospermes.' Et puis, c'est tout. L'idée ne vient à l'esprit de personne, que précisément ces genres singuliers ne sont peut-être pas des Magnoliacées, et qu'en tout cas, il y a lieu d'y regarder de plus près. Et si l'idée n'en vient pas, c'est sans doute parce que l'on admet implicitement que d'avoir telle ou telle sorte de bois secondaire, c'est chose sans aucune importance pour la Classification des plantes."

With van Tieghem's publication, what may perhaps be termed the exploratory phase of the study of *Trochodendron* and its "allies" came to a close. In the years since 1900 many students have given attention to the group, and those interested in the larger aspects of family relationships have proposed their own solutions. The principal detailed studies are here mentioned briefly.

Solereder, in 1900 (25), published an important detailed morphological study of *Cercidiphyllum,* pointing out that its floral characters do not seem to be those of the Ranales; he referred the genus, and also *Eucommia,* to the Hamamelidaceae. Wagner (28) presented in 1903 a study of the morphology of the branchlets and inflorescence of *Trochodendron.* Also in 1903, Hallier (6) discussed the relationships of the five genera under consideration, suggesting that all demonstrate affinities with the Hamamelidaceae; he further emphasized this opinion in 1904 (7) and 1905 (8, 9) — it is an opinion which has found no supporters and which is scarcely substantiated by the facts. Harms' treatment in Engl. & Prantl, Nat. Pfl. Nachtr. 3: 110–112 (1906) is important because of its concise summary of then current opinions, including van Tieghem's, certain of whose family names were properly latinized. Some of these family names now came into general usage, the Cercidiphyllaceae and Eucommiaceae being accepted by Engler in the sixth edition of his Syllabus (1909).

From a taxonomic point of view, the most carefully documented work on the Chinese representatives of *Tetracentron, Cercidiphyllum, Euptelea*, and *Eucommia* has been that of Rehder and Wilson, in Sargent's Plantae Wilsonianae (vol. 1, 1913). In very detailed studies of the Cercidiphyllaceae in 1916 (11) and 1918 (12), Harms concluded that the family is correctly placed in the Ranales. An elaborate study of the leaf-anatomy of *Cercidiphyllum* was published in 1923 and 1924 by Weisse (29). The family Eucommiaceae was treated in excellent detail by Harms in 1930 (13) and was placed in the Rosales following the Roridulaceae. The Flora of Japan by Makino and Nemoto (Nippon-Shokubutsu-Sôran, ed. 2. 1931) is perhaps the first major floral effort to recognize the family Eupteleaceae as distinct. In 1933 McLaughlin (21), on the basis of his examination of their wood anatomy, suggested that *Euptelea* and *Tetracentron* be made the types of two separate families, although the use of such family names was avoided. In the same year, Harms (14) revised his conclusions on the Eucommiaceae to place the family in the Urticales. This position was given support by Tippo's careful study of the Eucommiaceae in 1940 (27).

In the two preceding paragraphs I have listed only the recent major studies pertaining to this group of plants. There remain to be considered the opinions of various recent phylogenists. The opinion of Hallier has already been mentioned, and to a certain extent this doubtless influenced that of Lotsy, who in 1911 (20) placed *Tetracentron* in the Magnoliaceae, *Trochodendron* and *Euptelea* in the Trochodendraceae, and *Eucommia* and *Cercidiphyllum* in the Hamamelidaceae, suggesting the derivation of the latter family from a ranalian ancestor through this series. Bessey, in 1915 (1), placed the Trochodendraceae and Cercidiphyllaceae in the Ranales and the Eucommiaceae in the Rosales, but unfortunately he offered no opinion as to the position of *Euptelea* and *Tetracentron*. Hayata (15) agreed with Bessey in the position of the three above-mentioned families. Hutchinson, in his several discussions pertaining to the ranalian complex (17, 18, 19), placed the Trochodendraceae (including *Trochodendron* and *Euptelea*) and Cercidiphyllaceae in the Magnoliales and the Eucommiaceae in the Hamamelidales; he did not account for *Tetracentron*. Wettstein's treatment in 1935 (30) has the Eucommiaceae in the Urticales, the Cercidiphyllaceae and Eupteleaceae in the Hamamelidales, and the Trochodendraceae (*Trochodendron* only) in the Polycarpicae following Magnoliaceae, which includes *Tetracentron*. In the most recent edition of Engler's Syllabus, Diels (4) has placed the Trochodendraceae (including *Trochodendron* and *Euptelea*) and Cercidiphyllaceae in the Ranales and the Eucommiaceae in the Rosales, while *Tetracentron* is not mentioned.

From these more or less current opinions, the reader may observe that agreement as to the delimitation and phylogenetic position of these groups has not been reached; yet it is evident that progress has been made and that these small genera have appeared highly important to numerous stu-

dents. We propose to discuss the genera and to indicate the characters that have led us to the opinion that each represents a unigeneric family. *Eucommia* may be left out of consideration, for Tippo (27) has ably summarized the evidence for placing this genus in the Urticales. *Cercidiphyllum* remains highly puzzling and must still be examined in great detail; we feel that it may be included in the Ranales, but its exact relationships appear very questionable. The remaining genera — *Trochodendron, Tetracentron,* and *Euptelea* — will be discussed from a taxonomic viewpoint in this paper and a subsequent one.

## TROCHODENDRACEAE

**Trochodendraceae** Prantl in E. & P. Nat. Pfl. 3(2): 21, p. p. (quoad *Trochodendron*). 1888; Sargent in Garden and Forest 7: 105, p. p. 1894, For. Fl. Jap. 13, p. p. 1894; Oliv. in Hook. Ic. Pl. 24: *pl. 2361,* p. p. (quoad *Trochodendron*). 1895; Harms in Ber. Deutsch. Bot. Ges. 15: 359, p. p. (quoad *Trochodendron*). 1897, in E. & P. Nat. Pfl. Nachtr. 1: 158, p. p. 1897; Engl. Syllabus ed. 2. 116, excl. *Cercidiphyllum*. 1898; v. Tiegh. in Jour. de Bot. 14: 262 seq. (Trochodendracées). 1900; Engl. Syllabus ed. 3. 123, p. p. 1903, ed. 4. 124, p. p. 1904; Schneid. Ill. Handb. Laubholzk. 1: 269, excl. *Euptelea*. 1904; Harms in E. & P. Nat. Pfl. Nachtr. 3: 110. 1906; Boodle & Fritsch, Solereder's Syst. Anat. Dicot. 31, 809, p. p. 1908; Engl. Syllabus ed. 6. 132, excl. *Euptelea*. 1909; Lotsy, Vortr. Bot. Stammesg. 3: 456, excl. *Euptelea*. 1911; Bessey in Ann. Mo. Bot. Gard. 2: 128. 1915; Engl. & Gilg, Syllabus ed. 8. 190, excl. *Euptelea*. 1919; Hayata, Ic. Pl. Formos. 10: 189. 1921; Hutchinson in Kew Bull. 1921: 186. 1921; Chun, Chin. Econ. Trees 128, p. p. 1922; Engl. & Gilg, Syllabus ed. 9, 10. 203, excl. *Euptelea*. 1924; Hutchinson in Kew Bull. 1924: 120. 1924, Fam. Fl. Pl. Dicot. 85, excl. *Euptelea*. 1926; Rehder, Man. Cult. Trees & Shrubs 212, excl. *Euptelea*. 1927, ed. 2. 244, excl. *Euptelea*. 1940; Makino & Nemoto, Nippon-Shokubutsu-Sôran (Fl. Jap.) ed. 2. 307. 1931; Wettst. Handb. Syst. Bot. ed. 4. 2: 690. 1935; Diels, Engl. Syllabus ed. 11. 205, excl. *Euptelea*. 1936; Masamune, Short Fl. Formos. 63. 1936; Nemoto, Nippon-Shokubutsu-Sôran-Hoi (Fl. Jap. Suppl.) 208. 1936.

*Magnoliaceae* subord. *Illicieae* Endl. Enchir. Bot. 428, p. p. (quoad *Trochodendron*). 1841.

*Magnoliaceae* trib. *Illicieae* sensu Walp. Rep. 1: 72, p. p. (quoad *Trochodendron*). 1842, 2: 747, p. p. (quoad *Trochodendron*). 1843; non DC.

*Magnoliaceae* II. *Wintereae* Lindl. Veg. Kingd. ed. 2. 419, p. p. (quoad *Trochodendron*). 1847, ed. 3. 419, p. p. 1853.

*Trochodendreae* Seem. in Jour. Bot. 2: 238 (order), excl. *Euptelea*. 1864; Eichl. in Flora 48: 12 (familie), excl. *Euptelea*. 1865, in Jour. Bot. 3: 150 (order), excl. *Euptelea*. 1865.

*Magnoliaceae* trib. *Trochodendreae* Benth. & Hook. f. Gen. Pl. 1: 954, excl. *Euptelea*. 1867; Baill. Hist. Pl. 1: 164, p. p. 1868–69; Durand, Ind. Gen. Phan. 4, p. p. (quoad *Trochodendron*). 1888; Finet & Gagnep. in Bull. Soc. Bot. Fr. 52: Mém. 4: 23 (Trochodendrées), p. p. (quoad *Trochodendron*). 1905 (repr. Contr. Fl. As. Or. 2: 23. 1907).

*Magnoliaceae* III. *Trochodendreae* Eichl. Blüthendiagr. 2: 150, excl. *Euptelea*. 1878.

*Trochodendraceae* II. *Trochodendroideae* Harms in Ber. Deutsch. Bot. Ges. 15: 359. 1897, in E. & P. Nat. Pfl. Nachtr. 1: 159. 1897.

The Trochodendraceae is in this paper interpreted as a unigeneric family, whereas most of the above references are to a more inclusive concept. For the most part, *Euptelea* has been included in the family, while many writers have extended it to include *Cercidiphyllum* and even *Eucommia;* except by a few writers *Tetracentron* has been excluded, but this genus is by

far the closest relative of *Trochodendron.* Of the references listed above, the following interpret the Trochodendraceae in the limited unigeneric sense: van Tieghem (1900), Makino & Nemoto (1931), and Wettstein (1935). Harms' subfamily Trochodendroideae (1897) is also limited to the single genus *Trochodendron.*

**Trochodendron** Sieb. & Zucc. Fl. Jap. **1**: 83. 1838; Endl. Gen. Pl. 839. 1839, Enchir. Bot. 428. 1841; Steudel, Nom. ed. 2. **2**: 720. 1841; Endl. Gen. Pl. Suppl. **2**: 73. 1842; Walp. Rep. **1**: 72. 1842; Meisn. Pl. Vasc. Gen. Pars Alt. 339. 1843; Walp. Rep. **2**: 747. 1843; Dietr. Syn. Pl. **3**: 216. 1843; Lindl. Veg. Kingd. ed. 2. 419. 1847, ed. 3. 419. 1853; Miers in Ann. Mag. Nat. Hist. III. **2**: 115. 1858, Contrib. Bot. **1**: 144. 1861; Benth. & Hook. f. Gen. Pl. **1**: 17. 1862, 954. 1867; Seem. in Jour. Bot. **2**: 237. 1864; Eichl. in Flora **48**: 12. 1865, in Jour. Bot. **3**: 150. 1865; Baill. Hist. Pl. **1**: 163, 191. 1868–69; Pfeiff. Nomencl. Bot. **2**: 1496. 1874; Eichl. Blüthendiagr. **2**: 150. 1878; Durand, Gen. Ind. Phan. 4. 1888; Prantl in E. & P. Nat. Pfl. **3**(2): 23. 1888; Harms in Ber. Deutsch. Bot. Ges. **15**: 350. 1897, in E. & P. Nat. Pfl. Nachtr. **1**: 159. 1897; Solereder in Ber. Deutsch. Bot. Ges. **17**: 397. 1900; v. Tiegh. in Jour. de Bot. **14**: 262. 1900; Hall. f. in Ber. Deutsch. Bot. Ges. **23**: 89 (*Trochodendrum*). 1905, in New Phyt. **4**: 157 (*Trochodendrum*). 1905; Harms in E. & P. Nat. Pfl. Nachtr. **3**: 111. 1906; Lotsy, Vortr. Bot. Stammesg. **3**: 456. 1911; Rehder in Bailey, Stand. Cycl. Hort. **6**: 3386. 1917; Hutchinson, Fam. Fl. Pl. Dicot. 85. 1926; Rehder, Man. Cult. Trees & Shrubs 213. 1927, ed. 2. 245. 1940; Wettst. Handb. Syst. Bot. ed. 4. **2**: 689. 1935.

*Gymnanthus* Jungh. in Tijdschr. Nat. Gesch. Phys. **7**: 308. 1840.

A monotypic genus of trees; branchlets terete, marked at the nodes with conspicuous pseudoverticillate leaf-scars and, above these, by the narrow scars of bud-scales, terminated by a conspicuous ovoid bud, the bud-scales numerous, imbricate, the innermost the largest; stipules none; leaves pseudoverticillate in clusters of (4–) 6–12 at apex of branchlets, those of the lower verticils often subpersistent, some of the leaves never fully developing; leaves with usually canaliculate petioles and simple coriaceous serrulate pinnate-nerved blades; inflorescence a raceme-like modified pleiochasial cyme,[1] terminal at inception, soon appearing axillary, essentially epedunculate, the hermaphrodite flowers more closely arranged distally than proximally, each subtended by a soon caducous bract; pedicels slender (the proximal ones the longest), usually bearing 2–5 inconspicuous bracteoles on the torus or just below it and sometimes another 1–3 farther down (these linear, bract-like); perianth none (unless the above-described toral bracteoles are perianth-remnants); pedicel swollen into the subcoriaceous obconical torus, this bearing the numerous stamens on its rugulose outer surface in 3 or 4 superimposed series (uppermost stamens the longest persistent, the lowermost soon caducous and leaving scars) and the several carpels in a single whorl at its apex; stamens with filiform filaments and basifixed oblong 4-sporangiate mucronulate anthers, the thecae dehiscing by lateral clefts for their entire length; carpels fused to the torus at base, spreading, at anthesis laterally coalescent, the ovary unilocular, with 2 rows of anatropous ovules borne near the ventral suture, abruptly narrowed distally into a style, this (like the ovary) distinctly conduplicate and deeply canaliculate ventrally; fruit a follicetum composed of laterally

[1]A detailed discussion of the development of the inflorescence is given by Wagner (28), who considers it an interrupted "Primanpleiochasium." A further description will be given by Bailey and Nast in a subsequent paper.

coalescent follicles, dehiscing loculicidally on its upper (morphologically ventral) surface with a stellate rupture which often extends outward through the stylar portions of the follicles, the lateral walls of the follicles fused, thin-coriaceous or papyraceous, the outer (dorsal) and upper (ventral) follicle walls coriaceous and brittle; seeds dependent in two rows, mixed with sterile ovules of somewhat similar size, the outer integument modified into a mass of spongy tissue (sometimes wing-like) at the micropylar end, the funicle forming a ridge on one side of the embryoniferous portion and continued into a chalazal projection, the inner integument thin, membranaceous, the endosperm oleaginous, the embryo minute, ellipsoid, cleft at apex.

**Trochodendron aralioides** Sieb. & Zucc. Fl. Jap. 1: 84. *pl. 39, 40.* 1838; Endl. Enchir. Bot. 430. 1841; Walp. Rep. 1: 72. 1842, op. cit. 2: 747. 1843; Dietr. Syn. Pl. 3: 310. 1843; Sieb. & Zucc. in Abh. Bayer. Akad. Wiss. Math. Phys. Cl. 4(2): 185 [Fl. Jap. Fam. Nat. 1: 77]. 1846; Hoffm. & Schultes in Jour. Asiat. 20: 336. 1852 [repr. Noms Indig. Pl. Jap. Chin. 80. 1853]; Eichl. in Flora 47: 452 seq. 1864; Miq. in Ann. Mus. Bot. Lugd.-Bat. 2: 258 [Prol. Fl. Jap. 146]. 1866, in Adansonia 8: 211. 1868; Baill. Hist. Pl. 1: 163. 1868–69; Franch. & Sav. Enum. Pl. Jap. 1: 19. 1873; Pfeiff. Nomencl. Bot. 2: 1496. 1874; Prantl in E. & P. Nat. Pfl. 3(2): 23. *f. 19.* 1888; Tanaka, Illustr. Useful Pl. 1: *pl. 304.* 1891; Sargent in Garden and Forest 6: 75. 1893, For. Fl. Jap. 15. 1894; Groppler in Bibl. Bot. 6[Heft 31]: 15. *pl. 1 & 2, f. 5.* 1894; Hook. f. in Curtis's Bot. Mag. 120: *pl. 7375.* 1894; Masters in Gard. Chron. III. 15: 716. *f. 91.* 1894; Tanaka, Useful Pl. Jap. 81. 1895; Henry in Trans. As. Soc. Jap. 24: Suppl. 16 [List Pl. Formos.]. 1896; Parment. in Bull. Sci. Fr. & Belg. 27: 319. *pl. 11, f. 48.* 1896; Harms in Ber. Deutsch. Bot. Ges. 15: 350 seq. 1897; Bretschn. Hist. Eur. Bot. Disc. China 602. 1898; Matsum. in Bot. Mag. Tokyo 12: 54. 1898; Ito & Matsum. in Jour. Coll. Sci. Tokyo 12: 285 [Tent. Fl. Lutch.]. 1899; Shirasawa, Ic. Ess. For. Jap. 1: 75. 1899, *pl. 42.* 1900; v. Tiegh. in Jour. de Bot. 14: 262. 1900; Wagner in Ann. Naturhist. Hofmus. Wien 18: 409 seq. *f. 1, 2.* 1903; Veitch in Jour. Roy. Hort. Soc. 27: 865. *f. 197.* 1903; Schneider, Ill. Handb. Laubholzk. 1: 269. *f. 178, a-f.* 1904; Pynaert in Rev. Hort. Belge 30: 86. *pl.* 1904; Vilmorin & Bois, Frut. Vilmorin. 10. 1904; Finet & Gagnep. in Bull. Soc. Bot. Fr. 52: Mém. 4: 25. 1905 [repr. Contr. Fl. As. Or. 2: 25. 1907]; H. Mayr, Fremdl. Wald- und Parkbäume 522. 1906; Matsum. & Hayata in Jour. Coll. Sci. Tokyo 22: 11 [Enum. Pl. Formos.]. 1906; Purpus in Mitteil. Deutsch. Dendr. Ges. 1906: 41. 1906; Hayata, Fl. Mont. Formos. 44. 1908, Ic. Pl. Formos. 1: 30. 1911; Lotsy, Vortr. Bot. Stammesg. 456. *f. 277.* 1911; Matsum. Ind. Pl. Jap. 2(2): 98. 1912; Silva Tarouca, Unsere Freil.-Laubgehölze 365. 1913; Bean, Trees and Shrubs 2: 603. *fig.* 1914; Thompson & Bailey in Mem. N. Y. Bot. Gard. 6: 29. 1916; Rehder in Bailey, Stand. Cycl. Hort. 6: 3386. 1917; Kanehira, Formosan Trees 25. *fig.* 1917; Bailey & Thompson in Ann. Bot. 32: 507. 1918; Harms in Mitteil. Deutsch. Dendr. Ges. 1917 [26]: 86. 1918; Engl. & Gilg, Syllabus ed. 8. 191. 1919, ed. 9, 10. 203. 1924; Wilson in Jour. Arnold Arb. 1: 178. 1920; Hayata in Bot. Mag. Tokyo 39: (230). 1925; Mottet, Arbres et arbustes d'ornement 46. 1925; Hutchinson, Fam. Fl. Pl. Dicot. 85. *f. 6.* 1926; Nakai in Jour. Jap. Bot. 3: 86. *fig.* 1926; Rehder, Man. Cult. Trees & Shrubs 213. 1927, ed. 2. 245. 1940; Makino & Nemoto, Nippon-Shokubutsu-Sôran (Fl. Jap.) ed. 2. 307. 1931; Terasaki, Nippon Shokubutsu Zuhu (Ic. Fl. Jap.) *pl. 1599.* 1933; Nemoto, Nippon-Shokubutsu-Sôran-Hoi (Fl. Jap. Suppl.) 208. 1936; Diels, Engl. Syllabus ed. 11. 205. 1936; Masamune, Short Fl. Formos. 63. 1936; Kanehira, Form. Trees Indig. Isl. 178. *pl. 35, f. 130.* 1936.

*Gymnanthus paradoxus* Jungh. in Tijdschr. Nat. Gesch. Phys. 7: 308. 1840.

*Trochodendron longifolium* Maxim. in Ind. Sem. Hort. Petrop. 1865: 34, nomen. 1865; Miq. in Adansonia 8: 211, nomen. 1868; Baill. Hist. Pl. 1: 163, nomen. 1868–69; Hook. f. in Curtis's Bot. Mag. 120: sub *pl. 7375.* 1894; Nakai in Jour. Jap. Bot. 3: 86. *fig.* 1926.

*Trochodendron aralioides* var. *longifolium* Maxim. in Mél. Biol. 8: 371. 1871, in Bull. Acad. Sci. St. Pétersb. 17: 145. 1872; Franch. & Sav. Enum. Pl. Jap. 1: 19. 1873; Finet & Gagnep. in Bull. Soc. Bot. Fr. 52: Mém. 4: 25. 1905 [repr. Contr. Fl. As. Or. 2: 26. 1907]; Matsum. Ind. Pl. Jap. 2(2): 98. 1912; Makino & Nemoto, Nippon-Shokubutsu-Sôran (Fl. Jap.) ed. 2. 307. 1931.

*Trochodendron aralioides* var. *genuinum* Maxim. in Mél. Biol. 8: 372. 1871, in Bull. Acad. Sci. St. Pétersb. 17: 145. 1872.

*Trochostigma aralioides* Sieb. & Zucc. ex Wagner in Ann. Naturhist. Hofmus. Wien 18: 418, sphalm. 1903.

Tree, usually 5–20 m. high, occasionally said to be up to 25 m. high and with a trunk up to 5 m. in diameter (presumably in very old trees), glabrous throughout; branchlets brownish to cinereous, stout (2.5–7 mm. in diameter distally), the internodes striate when dry, usually 5–20 mm. (sometimes to 11 cm.) long; terminal bud up to 21 mm. long and 8 mm. broad, the bud-scales papyraceous, scarious-margined, the outer ones deltoid to broadly reniform, 1–3 mm. long, 2–5 mm. broad, carinate, subulate or cuspidate at apex, the inner ones progressively larger, the innermost ones oblong-elliptic, striate, up to 20 × 8 mm., obtuse or mucronulate at apex; petioles of mature leaves rugulose and usually deeply canaliculate above when dried, slightly enlarged at base, 2–9 cm. long, stout (usually 1–1.5 mm. in diameter, sometimes 0.7–3 mm.); leaf-blades often glossy above and rugulose on both surfaces when dried, olivaceous or brownish when dried, variable in shape[2] from broadly ovate to lanceolate-elliptic (or rhombic-ovate, rhombic-obovate, or elliptic), 5–12 (–14) cm. long, (2.5–) 3–7 (–8) cm. broad, rounded or broadly obtuse at base and shortly decurrent on the petiole, cuspidate or acuminate at apex (acumen obtuse, 3–12 mm. long), slightly thickened and narrowly recurved at margin, entire toward base, distally crenulate-serrulate (teeth 2–4 per centimeter, callose-mucronulate distally), the costa plane or slightly impressed or canaliculate above, raised or prominent beneath, the secondary nerves 5–7 (–8) per side, erecto-patent, lightly curved or straight, slightly raised on both sides or impressed above, the lower 2 or 3 pairs arising from the costa just above base, the veinlets immersed on both sides or forming a prominulous or impressed reticulum beneath; inflorescence 5–13 cm. long, 10–20 (–30-)-flowered, the rachis rugulose-striate, stout (1–2 mm. in diameter at anthesis, up to 3 mm. in fruit), the bracts thin-papyraceous, linear, 10–25 mm. long, 1–3 mm. broad; pedicels inconspicuously striate, at anthesis usually 15–35 (rarely to 50) mm. long, in fruit occasionally to 60 mm. long; toral bracteoles submembranaceous or papyraceous, deltoid-oblong or linear, obtuse, 0.5–1.7 mm. long, 0.3–0.6 mm. broad; stamens 40–70, spreading or often reflexed at anthesis, at length all caducous, 3.3–7 mm. long, the filaments narrowest at base, gradually swollen upward, 2.3–5 mm. long, the anthers 1–2 mm. long, 0.7–1 mm. broad and nearly as thick (dorsiventrally), obtuse at base, the connective projecting into a blunt short apical mucro; carpels (4–) 6–11, the ovary obovoid or angled by lateral pressure, at anthesis 2–2.5 mm. long and 1.5–2 mm. broad, the ovules usually 16–24, sometimes up to 30, the style 0.5–2 mm. long, 0.4–0.5 mm. in diameter at base, obtuse, often recurved distally, ventrally stigmatic in the apical one-half to two-thirds; mature folliceta 7–10 mm. in diameter; seeds often about 7–12 per follicle, mixed with an equal or larger number of sterile ovules (ovules showing about 65% sterility),

[2]See Plate V of the following paper in this Journal, by Bailey and Nast.

linear-ellipsoid, about 3–3.5 mm. long including projections at base and apex, the embryoniferous portion ellipsoid-oblong, 1.3–1.7 mm. long, 0.3 0.5 mm. broad; sterile ovules associated with seeds castaneous, irregularly linear in shape, somewhat papyraceous, 2.5–3.5 mm. long.

Distribution: Japan (central Honshu southward), Ryu Kyu Islands, and Formosa, at elevations between 300 and 2000 m. toward the north and up to 2700 m. in central Formosa (Arisan and Niitaka-yama). Although some of the earlier references cited above (e. g. Hoffman & Schultes in 1852, Miquel in 1866, Maximowicz in 1871, Franchet & Savatier in 1873, Hooker in 1894) mention the species as occurring in Hokkaido (Yezo), this appears to be erroneous. According to Sargent (For. Fl. Jap. 16. 1894), "Trochodendron . . . is certainly not an inhabitant of the alpine forests or of Hokkaido, as stated in some works on the Japanese flora, although, perhaps, it occurs in northern Hondo at the sea-level, as it is hardy in the gardens of Nikko at an elevation of 2,000 feet above the ocean . . . fine specimens of this tree are found scattered through public and private gardens in Tokyo and Yokohama." No herbarium specimens or authentic published records indicate the native occurrence of the species north of lat. 37° N.

In the following citations, the spelling of Japanese place names is made uniform, as far as possible, with that proposed in S. Gerr's A Gazetteer of Japanese Place Names (Cambridge, Mass., 1942). The islands and prefectures are arranged in general from northeast to southwest. A good map of Formosa, showing collectors' routes, has been published by Matsumura and Hayata (in Jour. Coll. Sci. Tokyo 22. 1906).

JAPAN: (Without other locality): *Buerger* (NY), *ex Herb. Lugd.-Bat.* (GH, M). Honshu: Tochigi Pref.: Hills east of Lake Chuzenji, *J. G. Jack,* Aug. 12, 1905 (A, GH); above Lake Chuzenji, *J. G. Jack,* Oct. 25, 1905 (A, GH); Gumma Pref.: Mitsumine-san, *Collector?,* July 16, 1908 (US); [Musashi Prov.], *S. Naito 21* (NY); Nagano Pref.: ["Prov. Senano", i. e. Shinano], *Tschonoski* (type coll. of *T. aralioides* var. *longifolium,* GH, M, US); Niegawa, at temple, *J. G. Jack,* Sept. 2, 1905 (A, GH); Ogawa, *J. G. Jack,* Sept. 5, 1905 (A, GH); Tsubakura-dake, *E. H. Wilson 7487* (A); Kanagawa Pref.: Mt. Tanjawa, *K. Sakurai,* Aug. 27, 1910 (A); Mt. Hakone, *L. Savatier 36* (NY); Shizuoka Pref.: Gotemba, *E. H. Wilson 6629* (A); Amagi-san, Izu, *Collector?,* May 25, 1897 (US); Gifu Pref.: [Mino Prov.], *K. Shiota 1951, 5086, 5556, 6678, 6992* (all A), *H. Mayr,* May 13, 1886 (A); Hiroshima Pref.: [Aki Prov.], *H. Mayr,* May 15, 1886 (A); Miyajima, *K. Sakurai,* July 17, 1910 (A). Shikoku: Kochi Pref.: Kiragawa, *S. Watanabe,* May 22, 1886 (UC); Nanokawa, Tosa, *K. Watanabe,* May 1888 (GH); Shiraga-yama, *E. H. Wilson,* Nov. 22, 1914 (A). Kyushu: Fukuoka Pref.: Hikosan, *Maximowicz,* 1863 (GH, M), *M. Takenouchi 1017* (US); Oita Pref.: Sobosan, *U. Faurie 3643* (A, UC); Nagasaki Pref.: Vicinity of Nagasaki, *Siebold* (type coll., GH); Kagoshima Pref.: Kirishima-yama [Nishi-Kirishima], *E. H. Wilson 6238* (A, M). Yakushima: (Without other locality): *E. H. Wilson 6041* (A, Ch, GH, US), *T. Komeda 22284* (A), *G. Masamune,* Aug. 7, 1924 (NY). Ryu Kyu Islands: Amami Oshima: Yuwan-dake, *R. Kanehira 3410* (NY). FORMOSA: Mt. Daiton, *S. Suzuki,* Oct. 1923 (A); Daiton Range, near Sozan, *E. H. Wilson 11231* (A, US), *T. Tanaka & Y. Shimada 10992* (A, Ch, M, NY, US), *T. Tanaka 5412* (A, NY); Tamsui, *A. Henry* (coll. *Morse*) *1398* (NY); Taihei-zan, *S. Suzuki,* Aug. 10, 1928 (A); eastern approach to Taihei-zan, *H. H. Bartlett 6103* (US); mountains west of Karenko, *E. H. Wilson 11161* (A); Niitaka-yama (Mt. Morrison), *R. Kanehira & S. Sasaki 21814* (US); Arisan, *U. Faurie,* Mar. 1915 (A), *439* (A), *E. H. Wilson 9716* (A, US), *J. L. Gressitt 197* (A, NY), *B. Hayata & S. Sasaki 877* (UC), *S. Sasaki 351* (A), *R. Kanehira 2874* (NY); South Cape, *A. Henry 1981* (NY); Mt. Tikusi, *Y. Simada 350* (A), *876* (UC); without detailed locality, *U. S. Expl. Exped.* (US). CULTIVATED: *C. S. Sargent,* Nov. 8, 1892 (A) (Nikko, Tochigi Pref., Honshu, Japan); Hort. Vilmorin, Verrières, France (A); *W. J. Bean,* June 1, 1909 (A) (Coombe Wood, England); *E. Walther,* June 1936 (A) (Golden Gate Park, San Francisco); *T. A. Havemeyer,* Nov. 16, 1926 (A) (Glen Head, Long Island, Hort. Havemeyer).

NATIVE NAMES: *Yama-kuruma; Yama-guruma; Nagaba-no-yamaguruma; O-mochi-no-ki; Torimochi-noki;* and variants. The most widely used native name, *Yama-kuruma* or a variant of it, apparently means mountain-wheel, referring to the habitat of the plant and the rotate arrangement of its leaves and floral parts. Siebold and Zuccarini based their generic name upon the Greek words for wheel and tree, ". . . ob foliorum in ramis staminumque in floribus dispositionem."

It has never been seriously proposed to recognize more than one species in *Trochodendron,* the binomial *T. longifolium* having been mentioned only casually or in synonymy, unless Nakai (in 1926, Japanese text) intended to accept it. However, several writers have accepted the narrow-leaved form as representing a distinct variety, var. *longifolium.* In order to weigh the value of varietal divisions within *T. aralioides,* I have carefully examined the cited specimens, coming to the conclusion that the species is reasonably coherent and that variations in leaf-shape are only individual.

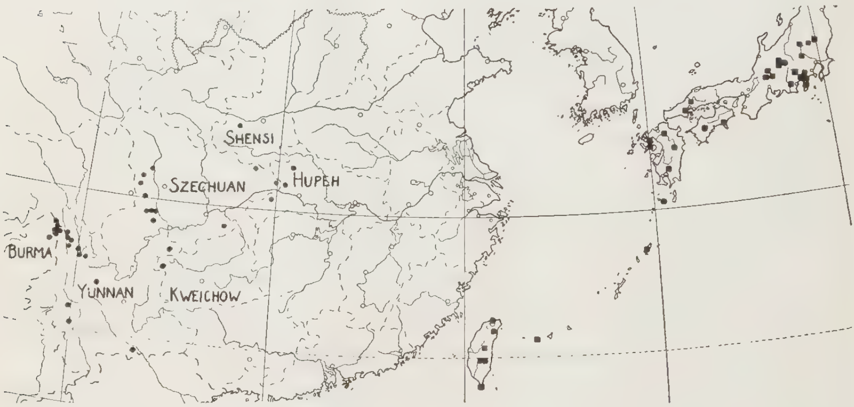


FIG. 1. Distribution of *Trochodendron aralioides* and *Tetracentron sinense.* Each solid square (*Trochodendron*) or solid dot (*Tetracentron*) represents an approximate locality from which herbarium specimens are available or have been cited in a reliable published record. Many of these localities are represented by several collections. From Goode's series of base maps, no. 226.

The material from Formosa, the Ryu Kyu Islands, and all the Japanese islands except Honshu has consistently broad leaves, except for some juvenile shoots accompanying *Wilson 6041* from Yakushima. The mature leaves of this collection, apparently from the same tree, are normally broad, suggesting that the narrow-leaved aspect, at least in some cases, may be merely a juvenile manifestation. The collections from Honshu, for the most part, have similarly broad leaves, but the type collection of var. *longifolium* and a few other specimens have the blades comparatively narnow, although there are many intergrades between this form and the more common broad-leaved form. No other characters separate var. *longifolium* from the typical aspect of the species, and this narrow-leaved form appears to be of little consequence. Geographically it may be said to

occur here and there toward the northern limits of the species, but it is also likely to occur as a juvenile form of normally broad-leaved individuals.

Although it is an evergreen tree, with leaves which persist for two to four years, *Trochodendron aralioides* shows a definite annual cycle of development. The terminal buds apparently open in April or early May, after which the inflorescence and the pseudoverticil of new leaves expand very rapidly. The new bud can already be observed at the growing point among the developing leaves. Fully mature flowers are found during May, and toward the end of this month or during June the stamens are lost, leaving the maturing carpels. The fruits develop during the summer, and dehiscence of the carpels may take place as early as August, although this commonly does not occur until October or November. By December the fruits have fully dehisced and most of the seeds have escaped. The new bud is well formed by late autumn. The old inflorescences, with opened and often shattered folliceta, frequently persist until spring or even until the new bud has opened and the cycle begun again in April.

## TETRACENTRACEAE

**Tetracentraceae** v. Tiegh. in Jour. de Bot. **14**: 355 seq. (*Tetracentracées*). 1900. [*Tetracentraceae* Harms in Ber. Deutsch. Bot. Ges. **15**: 357, nomen provis. 1897.]
*Magnoliaceae* V. *Tetracentroideae* Harms in Ber. Deutsch. Bot. Ges. **15**: 359. 1897.
*Magnoliaceae* IV. *Tetracentreae* Harms in E. & P. Nat. Pfl. Nachtr. **1**: 158. 1897.
*Magnoliaceae* Sect. *Tetracentreae* Lotsy, Vortr. Bot. Stammesg. **3**: 453. 1911.

The first occurrence of the name Tetracentraceae is found in Harms' work of 1897, cited above, where he remarks: "Man könnte eine eigene Familie der *Tetracentraceae* auf sie gründen, die aber doch wohl an keiner anderen Stelle des Systems besser untergebracht würde als in der Nachbarschaft der *Magnoliaceae* und *Trochodendraceae*, . . ." I interpret this to be a provisional use of the family name and hence not acceptable publication under the International Rules. The propriety of van Tieghem's publication of this and other family names in French only is also open to question, but nevertheless I prefer to accept his publication as adequate, since his intention to propose new families in these cases is indisputable. If one wishes to apply Art. 23 of the International Rules of Botanical Nomenclature (ed. 3. 1935) stringently, the present treatment may be considered the first valid use of the family name Tetracentraceae.

**Tetracentron** Oliv. in Hook. Ic. Pl. **19**: *pl. 1892*. 1889; Prantl in E. & P. Nat. Pfl. 3(2): 273. 1891; Harms in Ber. Deutsch. Bot. Ges. **15**: 350. 1897, in E. & P. Nat. Pfl. Nachtr. **1**: 158. 1897; v. Tiegh. in Jour. de Bot. **14**: 355. 1900; Hall. f. in Ber. Deutsch. Bot. Ges. **23**: 89 (*Tetracentrum*). 1905, in New Phyt. **4**: 157 (*Tetracentrum*). 1905; Lotsy, Vortr. Bot. Stammesg. **3**: 453. 1911; Rehder in Bailey, Stand. Cycl. Hort. **6**: 3322. 1917; Chun, Chin. Econ. Trees 132. 1922; Rehder, Man. Cult. Trees & Shrubs 261. 1927, ed. 2. 253. 1940; Hu in Contr. Biol. Lab. Sci. Soc. China 5(5): 9. 1929; Wettst. Handb. Syst. Bot. ed. 4. **2**: 689. 1935; Lee, For. Bot. China 493. 1935; Chen, Ill. Man. Chin. Trees & Shrubs 302 (*Tetracendron*). 1937.

A monotypic genus of trees; branchlets bearing alternately directed short shoots at the nodes, sometimes forking by means of occasional lateral long shoots (short shoots very rarely interrupted and giving rise to long shoots);

short shoots conspicuously marked throughout by the crowded concentric scars of fallen leaves and bud-scales, at anthesis and in early fruit terminated by a bud (which is at first enclosed by the stipular sheathing base of the petiole and is at length free), a single subterminal leaf, and a single inflorescence arising below the petiole and dorsal or lateral to it:[3] short shoot bud composed of two imbricate bracts, a terminal (at inception) incipient inflorescence, and a secondary collaterally terminal (actually axillary at base of inflorescence) bud which consists of a single bract, a developing leaf with its dorsal or lateral surface toward the incipient inflorescence, and the primordium of the short shoot (enclosed in the stipular base of the young petiole); bracts of the terminal short shoot bud coriaceous, strongly concave; leaves simple, deciduous; petioles of mature leaves alate proximally with stipular flanges which form a sheathing base enclosing the terminal bud; leaf-blades thin, serrate-margined, palmate-veined; inflorescence a slender spike, short-pedunculate; flowers hermaphrodite, numerous, aggregated in clusters of 4, the adjacent clusters alternately placed (this arrangement often scarcely apparent at anthesis due to abortion of some flowers or irregular development, the flowers thus sometimes appearing irregularly spaced on the rachis), each flower sessile in the axil of a minute bract; sepals 4, obscurely imbricate at base (lateral sepals outside the upper and lower sepals at both margins); petals none; torus inconspicuous, flattened; stamens 4, borne on torus at base of sepals and opposite them, the filaments slender, the anthers basifixed, erect, the connective stout, subclavate, truncate-rounded at apex, not or scarcely exceeding the thecae, the sporangia 4, lateral, the thecae dehiscing by 2 longitudinal clefts, the resultant valves at length fully reflexed, oblong, rounded at each end; carpels 4, alternate with stamens and sepals, laterally coalescent proximally at anthesis, carnose, the ovary triquetrous, unilocular, bearing the stylar portion from its inner angle, the style subulate, conduplicate, at first erect, soon recurved, stigmatic along the ventral suture for most of its length; placentae 2, parallel along the ventral suture of the ovary, the ovules attached to the placenta near middle of locule, horizontal at anthesis; style becoming more sharply recurved soon after anthesis, the ovary becoming strongly arched by rapid elongation of its ventral surface; fruit a follicetum composed of 4 laterally coalescent follicles, the sepals persistent, the mature carpels firmly concrescent along the lower part of the ventral suture, greatly developed ventrally, the dorsal margin and style not increasing in size after anthesis, the carpels loculicidally dehiscent along the entire exposed portion of the ventral suture to base of the persistent style, the adjacent carpel-halves at length falling together, the pericarp and dissepiments (formed by fusion of adjacent walls) firmly papyraceous; seeds pendulous from apex of locule (i. e. from midde of ventral suture, now apical in position), the outer integument modified into a spongy tissue which projects in two or three lateral wing-like ridges, sometimes more massive at the micropylar end, the funicle forming a ridge on one side of the embryoniferous portion and continued into a chalazal projection which may be wing-like, the inner integument thin, membranaceous, the endosperm oleaginous, the embryo minute, subglobose or ellipsoid, becoming obscurely cleft at apex.

[3]The details of the complex pattern of foliation and inflorescence structure will be discussed in a subsequent paper by Bailey and Nast.

**Tetracentron sinense** Oliv. in Hook. Ic. Pl. 19: *pl. 1892.* 1889; Prantl in E. & P. Nat. Pfl. 3(2): 273. 1891; Henry in Kew Bull. 1897: 407. 1897; Bretschn. Hist. Eur. Bot. Disc. China 779. 1898; v. Tiegh. in Jour. de Bot. 14: 356. 1900; Diels in Bot. Jahrb. 29: 323. 1900; Vilmorin & Bois, Frut. Vilmorin. 10. 1904; Finet & Gagnep. in Bull. Soc. Bot. Fr. 52: Mém. 4: 26. 1905 (repr. Contr. Fl. As. Or. 2: 26. 1907); Bean in Kew Bull. 1909: 356. *fig.* 1909; Lotsy, Vortr. Bot. Stammesg. 3: *f. 274* (generic name only). 1911; Wilson, Veg. W. China 19. 1912; Schneider, Ill. Handb. Laubholzk. 2: 927. *f. 579.* 1912; Rehder & Wilson in Sargent, Pl. Wils. 1: 417. 1913; Silva Tarouca, Unsere Freil.-Laubgehölze 362. 1913; Wilson, Nat. in W. China 1: 37, 52, 177. 1913; Bean, Trees and Shrubs 2: 584. 1914; Thompson & Bailey in Mem. N. Y. Bot. Gard. 6: 29. 1916; H. Lév. Cat. Pl. Yun-Nan 175. 1916; Rehder in Bailey, Stand. Cycl. Hort. 6: 3322. 1917; Harms in Mitteil. Deutsch. Dendr. Ges. 1917 [26]: 85. 1918; Bailey & Thompson in Ann. Bot. 32: 507. 1918; Chun, Chin. Econ. Trees 132. *pl. 50.* 1922; Mottet, Arbres et arbustes d'ornement 46. 1925; Wilson in Jour. Arnold Arb. 7: 239. 1926; Rehder, Man. Cult. Trees & Shrubs 261. 1927, ed. 2. 253. 1940; Hu & Chun, Ic. Pl. Sin. 1: 23. *pl. 23.* 1927; Hu in Contr. Biol. Lab. Sci. Soc. China 5(5): 9. 1929; Cox in New Flora & Silva 6: 11. *f. 5.* 1933; Lee, For. Bot. China 493. *pl. 138.* 1935; Chen, Ill. Man. Chin. Trees & Shrubs 302. *fig.* 1937; Merr. in Brittonia 4: 53. 1941; Fang in Ic. Pl. Omeiens. 1 (2): *pl. 58.* 1944.

Tree up to 30 m. high, glabrous throughout, the trunk often exceeding 1 m. in diameter (sometimes up to 20 ft. in girth, according to E. H. Wilson), the crown much-branched, often somewhat flat; young branchlets (long shoots) purpurascent and slightly angled, soon terete, cinereous, and inconspicuously lenticellate, distally 1.5–4 mm. in diameter, faintly flexuose or essentially straight, the internodes (on long shoots) usually 2–5 cm. long; short shoots up to 4 cm. long, 2–4 (–5) mm. in diameter; outer bract (of the terminal short shoot bud) oblong-elliptic, up to 15 mm. long and 9 mm. broad when expanded, obtuse at apex, entire and scarious at margin, the inner bract similar but slightly smaller and callose-mucronulate at apex; petioles of mature leaves slender (0.7–1.5 or rarely 2 mm. in diameter), rugulose and often striate when dried, semi-terete, canaliculate toward base and sometimes distally, 2–4 cm. long, the stipular flanges papyraceous or scarious, linear, 7–15 mm. long, 0.5–1.5 mm. broad, rounded or subacute at apex and abruptly decurrent on the petiole; mature leaf-blades papyraceous or chartaceous when dry, green, becoming olivaceous or fuscescent when dry, slightly paler beneath, ovate or ovate-elliptic,[4] 7–16 cm. long, 4–11.5 cm. broad, deeply or shallowly cordate at base with rounded sinus or rarely truncate-rounded, acuminate at apex (tip elongate-deltoid, 6–15 or rarely 20 mm. long, callose-tipped), regularly and finely serrate at margin except within the basal sinus (teeth 3–7 per centimeter, callose-tipped, subacute or obtuse, rarely subspinulose and with narrowly recurved margins), the principal nerves 5 or 7, spreading from base, fairly straight, inconspicuously anastomosing, slightly impressed or nearly plane above, strongly elevated beneath, the lateral nerves with several outwardly directed ramifications, the veinlets freely anastomosing, forming a lax reticulum which is immersed to faintly prominulous above and prominulous or sharply raised beneath (or with the ultimate veinlets impressed or immersed); inflorescence slender (rachis and peduncle 0.6–1 mm. in diameter, striate when dried), 7–20 cm. long, the peduncle 5–22 mm. long; flowers about 80-125 (in bud, often fewer at anthesis), the

[4]See Plate VI of the following paper in this Journal, by Bailey and Nast.

flower-subtending bracts papyraceous, broadly deltoid, 0.3–0.5 mm. long, 0.4–0.7 mm. broad at base, rounded or obtuse at apex; sepals papyraceous, oblong or deltoid-suborbicular, at anthesis 1–1.5 mm. long and slightly narrower, rounded at apex, entire at margin; filaments subterete or slightly flattened, (0.5–) 1.5–3 mm. long at anthesis, the anthers oblong, at anthesis 0.4–0.8 mm. long and 0.5–0.7 mm. broad (unopened); carpels 1.3–1.7 mm. long at anthesis, the style 0.6–1 mm. long, the ovules usually 6, sometimes 5, oblong-obovoid, subacute at base, rounded at apex, slightly dorsiventrally flattened; mature folliceta oblong, 2.5–4.5 mm. long, 2–3.5 mm. broad, depressed at apex; seeds usually 6 per follicle (sometimes 4 or 5, rarely fewer and very rarely only 1, the ovules showing about 10% sterility on the average), linear, 2–3.5 mm. long including projections at base and apex, 0.5–0.7 mm. broad including lateral ridges, the embryoniferous portion 0.8–1.5 mm. long.

DISTRIBUTION: South-central China, in the Provinces of Shensi, Hupeh, Szechuan (doubtless also in eastern Sikang), Kweichow, and Yünnan, and in northern Burma, at altitudes from 1600 to 3600 m. The species is not known north of lat. 34° N. nor east of long. 111° E. The most southern collections of it thus far known are Henry's from south of the Red River in Yünnan, near the Indo-Chinese frontier, at a latitude probably somewhat lower than 23° N. Henry (in Kew Bull. 1897: 100, 407. 1897) reports the species as very common in this region, and therefore it may be expected in adjacent Indo-China. Wilson (Nat. in W. China 1: 37, 52. 1913) describes *Tetracentron sinense* as one of the commonest trees in the region of the Hupeh-Szechuan frontier north of the Yangtze. It is also common in western Szechuan and northwestern Yünnan, where it is often reported as the most abundant species of tree.

In the following citations, localities are arranged in general from northeast to southwest. Dr. J. F. Rock has very kindly checked the spelling of the localities listed below.

CHINA: SHENSI: Tai-pai Shan, *W. Purdom 669* (A), *670* (A, GH, US). HUPEH: Western Hupeh (no other data), *E. H. Wilson 2156* (A, NY, US); Huan-tsao, western Hupeh, *W. Y. Chun 4139* (A); Fang Hsien, *E. H. Wilson 659* in pt. (A); Fang Hsien and Chien-shih Hsien (without other indication), *A. Henry 6243* (GH), *6690* (A, GH, US), *7417* (GH, US) (all COTYPE COLLS.). SZECHUAN: "Tchen-kéou-tin" (Chengkou?), *P. Farges* (NY); summit of Fei-yüeh, Chien-chi Hsien, *E. H. Wilson 4328* in pt. (A); western Szechuan (no other data), *E. H. Wilson 659* in pt. (GH, US), *659a* in pt. (A); Fei-yüeh Ling, *W. C. Cheng 1992* (A, NY, US); west of Wen-chuan Hsien, *W. C. Cheng 3419* (A, NY, US); Pan-lan Shan, west of Kuan Hsien, *E. H. Wilson 4328* in pt. (A, US); Mupin, *E. H. Wilson 659a* in pt. (A); Mt. Tien-chuan, *Y. S. Liu 1347* (A); O-mei Hsien, *S. S. Chien 6105* (A); O-mei Shan, *E. H. Wilson 4721* (A), *W. P. Fang 2653* (A, NY), *2725* (A, NY), *6705* (A, NY), *12781* (A, US), *C. Y. Chiao & C. S. Fan 514* (A); Wa Shan, *E. H. Wilson 659a* in pt. (A); Ma-pien Hsien, *F. T. Wang 22990* (A). KWEICHOW: Huei-hsiang-ping, Fan-ching Shan, *A. N. Steward, C. Y. Chiao, & H. C. Cheo 663* (A, Ch, NY, US). YÜNNAN: *G. Forrest 14164* (A), *18488* (A); Chen-hsiung Hsien, *H. T. Tsai 52708* (A); northwestern Li-chiang, I-chi, *R. C. Ching 20854* (A); northwestern Li-chiang, A-hsi, *R. C. Ching 22034* (A); western Li-chiang, Kai-tzu on Yangtze, *K. M. Feng 2624* (A); Wei-hsi Hsien, *C. W. Wang 63646* (A), *64005* (A), *67836* (A), *H. T. Tsai 57831* (A), *59953* (A), *63072* (A); Wei-hsi Hsien, Yeh-chih, *C. W. Wang 68662* (A), *71750* (A); Mekong Valley, mountains of K'ang-p'u, Yeh-chih, and An-wa, *J. F. Rock 8932* (A, UC, US); Shang-pa Hsien, *H. T. Tsai 56579* (A); Mekong-Yangtze Divide, *G. Forrest 19641* (A); Doyon Lungpa Valley, Lu Chiang (Salwin River), *H. F. Handel-Mazzetti 8295* (A); Der-la, Ch'ang-p'u-t'ung, *C. W. Wang 66899* (A); Si-gi-tung, Ch'ang-p'u-t'ung, *C. W. Wang 67416* (A); Salwin Valley, Si-gi-tung, *T. T. Yü 19217* (A); Salwin-Chiu Chiang Divide, "Hevaty," *T. T. Yü 21073* (A); Taron-Taru Divide, Tang-teh-wang, *T. T. Yü 20013* (A); "Tchoan ouanho, tie so," near Pai-yen-ching, *S. Ten 185* (A, US); Mien-ning, Po-shang, *T. T. Yü 18061* (A); Shun-ning, Hi-la, Wu-mu-lung, *T. T. Yü 16699*

(A); south of Red River from Man-mei, *A. Henry 9744* (A, M, US); Feng-chen Ling, *A. Henry 9744A* (A). BURMA: Upper Burma, Kang-fang, *F. K. Ward 199* (A, NY). CULTIVATED: *Herb. Arnold Arb. 6722* (A) (in Arboretum, 1916, 1917); *Herb. Arnold Arb. 17408* (A) (in Arboretum, Oct. 13, 1912; grown from *Wilson 659*).

NATIVE NAMES: Apparently the only native name recorded for *Tetracentron,* except possibly in Chinese characters, is *Shui ch'ing shu,* mentioned by Diels in Bot. Jahrb. 29: 323. 1900.

*Tetracentron sinense* is a very stable species, within which no subspecific categories have been proposed. The available specimens are remarkable for their lack of variation, even the dimensions of foliar and floral parts being unusually consistent.

The collection of specimens at practically all seasons makes possible the following record of the annual cycle. During May, or possibly late in April, the buds open and each short shoot gives rise to an inflorescence and a single leaf. At this season the stipular petiole-base completely encloses the next short shoot bud. During June and July the flowers mature and the stipular flanges relax, permitting the new bud to enlarge slightly. In August the stamens fall and the carpels begin to mature. Between the end of August and early November each short shoot bears a single mature leaf and, if it is a fertile shoot, a mature fruiting inflorescence, from which the seeds gradually fall. The new bud now becomes fully developed and entirely free of the stipular flanges. The leaves fall between late October and December, but the fruiting spikes often persist until January. Between January and late spring the tree is in its winter condition, with fully developed buds terminating the short shoots.

## CONCLUSIONS

*Trochodendron* and *Tetracentron* are both so distinct from the Magnoliaceae, in numerous anatomical and morphological features, as to make any comparison of them with that family superfluous for the time being. *Trochodendron* is now universally recognized as belonging in a distinct family, but in many treatments *Tetracentron* is still treated as a member of the Magnoliaceae. Of all existing genera which might with some justification be placed in the same family as *Trochodendron, Tetracentron* is the only one deserving consideration. It is curious, therefore, that so many students have overlooked this affinity, at the same time linking *Euptelea* and even *Cercidiphyllum* with *Trochodendron.* This oversight can be accounted for if one realizes that *Trochodendron* and *Tetracentron* are superficially very unlike, their leaf-texture and venation and their inflorescence being strikingly dissimilar at first glance; furthermore, the presence of a perianth in *Tetracentron* and its putative absence in *Trochodendron* (the toral bracteoles having been ignored by most students) have been unduly stressed. Detailed study of the two genera, however, reveals important similarities — characters which they have in common and which are not shared by any other plants. *Euptelea* is very remotely related to *Trochodendron* and *Tetracentron,* as will be discussed in future papers, and yet this is the genus most closely associated with *Trochodendron* in most

treatments. *Cercidiphyllum,* although suggesting *Tetracentron* in certain superficial respects, is actually only a remote relative and is now universally placed in a unigeneric family. The family Winteraceae, which shares the character of vesselless wood with *Trochodendron* and *Tetracentron,* is so different in innumerable other respects (and also in details of wood anatomy) that comparison is superfluous. Van Tieghem's suggestion (26) that these three groups compose a distinct subclass of dicotyledons is not tenable, as their retention of the primitive vesselless wood appears to have been independent.

The following paragraph summarizes the important external morphological similarities and differences between *Trochodendron* and *Tetracentron.* Detailed consideration of some of these and of the internal characters will be the subject of a series of papers by Prof. Bailey and Dr. Nast, initiated in this Journal.

The branching of the genera is different, *Tetracentron* having short shoots alternately directed from the long shoots, while *Trochodendron* has only long shoots.. Actually, however, the method of foliation and inflorescing is somewhat similar in the two genera. The principal differences in these respects are as follows: leaves numerous in pseudoverticils in *Trochodendron,* solitary in *Tetracentron;* stipular flanges none in *Trochodendron,* present in *Tetracentron;* leaf-blades coriaceous and pinnate-nerved in *Trochodendron,* thin (papyraceous or chartaceous) and palmate-nerved in *Tetracentron.* The internodes (on short shoots) in *Tetracentron* are of course much more reduced than in *Trochodendron.* The inflorescence in *Trochodendron* is raceme-like and in *Tetracentron* spike-like or perhaps a true spike. The basal bracts (bud-scales) are numerous in *Trochodendron* and uniformly 2 in *Tetracentron.* The flower-subtending bracts are elongate and soon caducous in *Trochodendron,* minute and subpersistent in *Tetracentron.* In *Trochodendron* the flowers are comparatively few and laxly alternate on the rachis, while in *Tetracentron* the flowers are more numerous and are arranged in definite clusters of 4, the adjacent clusters being alternately placed. The pedicel in *Trochodendron* is long and the torus is bracteolate, while in *Tetracentron* the pedicel is entirely lacking. The perianth is lacking in *Trochodendron* (unless the toral bracteoles are interpreted as modified segments), while *Tetracentron* has 4 persistent sepals with a definite pattern of imbrication. The torus in *Trochodendron* is large, subcoriaceous, and obconical, while in *Tetracentron* it is flattened and inconspicuous. The stamens in *Trochodendron* are numerous and are whorled on the outer surface of the torus; in *Tetracentron* they are always 4 and are opposite the sepals. The stamens of the two genera are remarkably similar, the anthers of *Trochodendron* being faintly mucronulate and those of *Tetracentron* truncate-rounded at apex. The carpels of the two genera are fundamentally alike in structure, but different in details. Those of *Trochodendron* are several, larger, and with only a slight ventral overgrowth; those of *Tetracentron* are reduced to 4, small, and have a very pronounced

ventral overgrowth which results in a follicle of quite different shape. The ovules are numerous in *Trochodendron* and are attached to elongate placentae, while in *Tetracentron* they are 6 or fewer and are borne on the placentae only at the middle of the locule. The folliceta of the two genera are fundamentally similar but have a different aspect due to the strong ventral development of the carpel in *Tetracentron*. The seeds are numerous in *Trochodendron* and are associated with numerous sterile ovules, while in *Tetracentron* the seeds are 6 or fewer and there are proportionately fewer enlarged sterile ovules. The seeds in the two genera are remarkably similar, except that the outer integument in *Tetracentron* is more spongy and wing-like. The endosperm is abundant in both genera, perhaps somewhat more oily in *Tetracentron*, while the embryo is similarly placed and minute in both cases.

Whether the two genera are placed in the same or in different families depends upon the importance of the characters mentioned above. The similarities are striking, but the fundamental differences are also striking. In view of these differences, we believe that the erection of two families is justified.

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ARNOLD ARBORETUM,
HARVARD UNIVERSITY.

# MORPHOLOGY AND RELATIONSHIPS OF TROCHODENDRON AND TETRACENTRON, I. STEM, ROOT, AND LEAF

I. W. Bailey and Charlotte G. Nast

*With six plates*

## INTRODUCTION

Owing to their retention of a primitive cambium and a vesselless type of xylem, *Trochodendron* and *Tetracentron* are fully as significant as the Winteraceae, Degeneriaceae, and Himantandraceae in discussions regarding the origin and phylogeny of the angiosperms. Furthermore, as indicated by Dr. Smith in the preceding article in this Journal, the opinions of taxonomists and morphologists concerning the relationships and classification of the two monotypic genera are exceedingly diversified and contradictory. It seemed advisable, accordingly, to utilize the extensive collections assembled by Dr. Smith as a broad basis for morphological as well as taxonomic re-investigations of these unusually significant genera. In presenting the results of our observations, we shall deal largely with morphological features that are incompletely or inadequately covered in the extensive literature.

## XYLEM

The most obvious structural characteristics of the wood of *Trochodendron* and *Tetracentron* were first described by Eichler (9) and Harms (12) and have subsequently been re-described by a succession of investigators, e.g. van Tieghem (22), Solereder (20), Kanehira (13), Sahni (17), Mathiesen (14), and McLaughlin (15). That the xylem of both the primary and secondary bodies of stems, roots, leaves, and inflorescences is entirely devoid of vessels or of vestiges of vessels has been clearly demonstrated by Thompson and Bailey (21) and Bailey and Thompson (3). Although the xylem of *Trochodendron* and *Tetracentron* is of a structurally unique type and not to be confused with that of any other known representative of the angiosperms or of the lower vascular plants, the woods of the two genera are so similar as to render difficult and uncertain the task of determining to which genus certain fossil woods from significant geological horizons of India, Greenland, and the northwestern United States actually are related.

As should be anticipated, see Bailey and Faull (1), the woods of *Trochodendron aralioides* Sieb. & Zucc. and *Tetracentron sinense* Oliv. exhibit certain ranges of anatomical variability not only within different parts of the same tree but also in homologous parts of trees grown under different environmental conditions. The most conspicuous and significant differences in the size and form of cambial initials and *pari passu* in the size,

form, and structural details of tracheary elements, rays, and parenchyma occur in passing from young shoots (e.g. of herbarium specimens) to the outer parts of large mature stems. Numerous specimens of the mature wood of *Trochodendron* are available for comparison with herbarium material, but the largest stem of *Tetracentron* that we have succeeded in obtaining has twelve growth layers and a woody cylinder approximately three centimeters in diameter. This specimen affords valuable clues regarding the succession of structural changes — particularly of the rays — that occur during the normal enlargement of a stem. The final form and distribution of the rays in old wood can be accurately reconstructed from the cambium and inner phloem of bark from an old tree collected by E. H. Wilson (no. *659*).

The available evidence indicates that certain anatomical features of the xylem of *Tetracentron* do not fall within the range of structural variability of *Trochodendron*. The most significant of these are the following. As shown by Thompson and Bailey (*21*), the first formed secondary xylem of stems and roots of *Tetracentron* is characterized by having numerous broad and abnormally short tracheids that subtend the vascular strands of leaves, buds, branches, and rootlets. These tracheids are profusely pitted on both their tangential and radial walls and appear to facilitate the movement of water from a stem into its appendages, or from rootlets into roots. More or less isolated and sporadically distributed radial seriations of these short tracheids extend outward into the subsequently formed secondary xylem. Whether they ever persist in the outer growth layers of old stems and roots unfortunately cannot be determined at present, but it seems likely that they may be found in tissue which subtends the bases of persistent branches. Such tracheids do not occur, however, in either the first-formed or the later-formed secondary xylem of *Trochodendron*.

The wood parenchyma of *Tetracentron* is of a structurally unique type and unlike that of any other vascular plant with which we are familiar. During the maturation of wood parenchyma in normal, uninjured stems of gymnosperms and dicotyledons, derivatives of the fusiform initials of the cambium divide approximately transversely, *Fig. 10,* forming vertically oriented, uniseriate strands of parenchymatous cells. In *Trochodendron,* the wood-parenchyma strands are uniseriate, *Fig. 11,* but the anticlinal partitions are more or less extensively and obliquely oriented. In *Tetracentron,* a large proportion of the derivatives of the long fusiform initials tend to divide first in more or less extensive, longitudinal anticlinal planes, *Fig. 12,* and subsequently the products of these divisions divide transversely or in various diagonal anticlinal planes. The fully matured parenchymatous strands, therefore, are largely biseriate, except in strands or parts of strands where divisions of the *Trochodendron*-type may have occurred. In transverse sections of normally developed, uninjured wood of Winteraceae, as of various gymnosperms — where the radial seriation of successively formed derivatives of the fusiform cambial initials is not disturbed by the enlargement of vessel members or by excessive apical elongation of

non-perforate tracheary elements — the parenchymatous strands appear as single cells of approximately the same tangential diameter as the tracheids. On the contrary, in transverse sections of the wood of *Tetracentron, Fig. 8,* a majority of the parenchymatous strands appear as paired cells and only relatively infrequently as single cells, i.e. where they are sectioned at the level of their tapered ends, *Fig. 12,* or other uniseriate parts. Occasional paired cells are encountered in transverse sections of *Trochodendron* where the uniseriate parenchymatous strands are sectioned at the level of their diagonal partitions, *Fig. 11,* just as three, or even four, such cells may be encountered in transverse sections of *Tetracentron* where the strands are sectioned at appropriate levels, *Fig. 12.*

The wood parenchyma of both *Trochodendron* and *Tetracentron* fluctuates from scanty to abundant, not only in different stems, but also in different growth layers of the same stem. In *Trochodendron,* the parenchymatous strands when abundantly developed tend to be diffusely distributed among the thicker-walled tracheids of the latewood, whereas in *Tetracentron* they may at times be loosely associated in zonal arrangements and may occur in the transitional as well as in the later-formed parts of the growth layers.

The eustele or vascular part of the primary body of stems is composed of more numerous discrete bundles in *Trochodendron* than in *Tetracentron.* This is correlated with significant differences in the number of strands in the leaves of the two genera. Since the first-formed multiseriate rays of the secondary body extend outward from the parenchymatous interfascicular parts of the eustele, the number of such rays in the first-formed growth layer of the secondary body of *Trochodendron* tends to be higher than in the homologous part of *Tetracentron.* During subsequent enlargment of the stems, the relationship becomes reversed,[1] the old wood of *Trochodendron* having conspicuously larger and fewer multiseriate rays per unit area, *Fig. 7,* than does comparable wood of *Tetracentron, Fig. 9.* Furthermore, the rays of the latter genus ultimately attain a more "homogeneous" form, i.e. the cells of the uniseriate rays are less vertically extensive than in *Trochodendron,* compare *Figs. 7* and *9.*

In growth layers of comparable widths and ages, the wood of *Tetracentron* is softer and lighter than that of *Trochodendron,* due largely to the fact that the tracheids of the latewood have thinner walls in relation to their cross-sectional area. In addition, the latewood tracheids of *Tetracentron* are of more uniformly rectangular outline as seen in transverse sections of the wood, and their radial seriation is less disturbed by excessive apical elongation of the tracheary elements during their maturation.

Mathiesen (14) has attempted to differentiate the woods of the two genera by the presence or absence of pits in the tangential walls of the latewood tracheids. Such pits fluctuate, however, from numerous to infrequent in *Trochodendron,* and, in young wood of *Tetracentron,* from very

[1]For detailed discussions of ray changes that occur during the enlargement of dicotyledons see Barghoorn (4, 5) and Bailey and Howard (2).

abundant (short tracheids) to scanty or absent (normal long tracheids). Not until numerous specimens of the older wood of *Tetracentron* are available for detailed investigation will it be possible to determine whether tracheary pitting provides under all conditions reliable criteria for differentiating the woods of the two genera.

## NODAL ANATOMY AND VASCULARIZATION OF THE LEAF

The petioles of the palmately veined leaves of *Tetracentron* have extensive stipular flanges that enclose the much elongated slender buds, *Fig. 35,* except during the final emergent phases of their development. At this level of the petiole, *Fig. 2,* there are three conspicuous vascular strands which tend to broaden and to coalesce at higher levels of the petiole and thus to form a cylindrical stele and a more or less continuous secondary body, *Fig. 1.* The coalescence of the expanded strands and the levels at which specific changes occur fluctuate from petiole to petiole. Not infrequently the vascular cylinder retains an opening or gap in its adaxial side, *Fig. 1,* or this opening may be partly occluded by a detached strand of vascular tissue. At the base of the lamina, the vascular cylinder or cylindrical complex of strands becomes abruptly dissociated into 5–7 bundles which form the principal veins of the leaf. At the nodal level of the stem, three vascular bundles depart from three widely separated parts of the circumference of the eustele, *Fig. 3,* leaving three conspicuous parenchymatous gaps in the secondary body. In other words the nodal anatomy of *Tetracentron* is stereotyped and stable and is characteristically of the so-called trilacunar type.

The highly polymorphic, pinnately veined leaves of *Trochodendron, Figs. 23–33,* are exstipulate and only infrequently have buds in their axils. The larger leaves of a pseudoverticil commonly have from 5–7 vascular strands in the base of their petioles, *Fig. 5.* These strands depart from a relatively restricted part of the circumference of the eustele of the stem, *Fig. 6,* and there is much less extensive "girdling" of the lateral bundles than in multilacunar Magnoliaceae. The vascular strands rapidly coalesce, forming an arc, *Fig. 4,* which extends upward through the petiole and midrib of the lamina. This arc-shaped strand may or may not be accompanied in the petiole by two small adaxially detached bundles. The smaller leaves of a pseudoverticil, as also the leaves of juvenile plants, commonly have three vascular bundles, but the strands may at times be reduced to two or even to a single vascular bundle with concomitant modifications in the nodal anatomy of the stem. Thus, the nodal anatomy of *Trochodendron* fluctuates from multilacunar to unilacunar and, in contrast to the stabilized trilacunar condition of *Tetracentron,* is plastic and variable.

## SCLERENCHYMA AND SECRETORY IDIOBLASTS

The secondary phloem of *Trochodendron* and *Tetracentron* does not exhibit the precocious flaring of the multiseriate rays and early stratification into narrow alternating arcs of soft bast and fibers that occur so characteristically in Magnoliaceae (*sensu stricto*), Degeneriaceae, and Annon-

aceae. Nor is there a sclerification of the multiseriate rays close to the cambium as in *Euptelea* and many Winteraceae. In bark from old stems of *Trochodendron*, the phloem is characterized by forming large irregular masses of dense non-fibrous, crystal-bearing sclerenchyma. The structurally closely similar sclerenchymatous tissue of *Tetracentron* occurs in less massive, more tangentially oriented clusters, as seen in transverse sections. Nests and diaphrams of sclerenchyma such as are formed so commonly in the pith of various woody ranalian families do not occur in *Trochodendron* and *Tetracentron.*

The leaves of *Trochodendron* are typified by the presence of profusely branching, sclerenchymatous idioblasts which are discussed by Dr. Foster in the following article in this Journal. These bizarre elements project into the large, intercellular spaces of the mesophyll. Similar intercellular spaces and sclerenchymatous idioblasts occur in the cortex of young stems and may be encountered in the pith, particularly in those parts of the stems where the leaves are congested in pseudoverticils. On the contrary, *Tetracentron* is characterized by the occurrence, in the leaf and the outer cortex of both stems and roots, of large more or less extensively elongated or branching secretory idioblasts. These elements have "resinous" contents which stain intensely with sudan IV, but differ markedly in form from the nearly spherical secretory cells of the Winteraceae, Magnoliaceae, and other woody ranalian families.

## STOMATA

Solereder (20) described the stomata of *Trochodendron, Tetracentron, Euptelea,* and *Cercidiphyllum* as being surrounded by several neighboring cells which are not of special form and orientation, in contrast to those of the Magnoliaceae (including *Drimys, Illicium, Schisandra,* and *Kadsura*) investigated by Vesque (23), where the guard cells are accompanied by subsidiary cells which are oriented parallel to the pore — the so-called rubiaceous type of stomata. On the contrary, Rao (16) maintains that the stomata of *Euptelea* and *Cercidiphyllum* are of Florin's (10) haplocheilic type, whereas those of *Trochodendron* and *Tetracentron* resemble the stomata of other investigated genera of the Magnoliales in being of his syndetocheilic type.[2] It should be emphasized in this connection, however, that Florin's classical investigations of stomata have dealt thus far with gymnosperms and that the terms haplocheilic and syndetocheilic were formulated specifically for use in dealing with gymnosperms. The terms clearly convey implications regarding the morphological form as well as the ontogenetic development of gymnospermous stomata and it is not certain as yet whether they should be adopted in dealing with angiosperms. The available evidence concerning angiospermic stomatal structures, summarized by De Bary (8), Solereder (20), and others, indicates that the morphological form and the ontogenetic development of these structures is exceedingly diversified and variable. Stomata with subsidiary cells oriented

[2]In the haplocheilic or simple-lipped type the guard cells are formed by a single division of an epidermal initial, whereas in the syndetocheilic or complex-lipped type both guard cells and subsidiary cells are derived from a single epidermal initial.

parallel to the pore may arise as products of the divisions of a single epidermal initial (rubiaceous type) or by divisions of more than one epidermal cell (false rubiaceous type). To classify the stomata of dicotyledonous genera as haplocheilic or syndetocheilic, particularly in discussions of putative relationships between angiosperms and gymnosperms, is at present premature and likely to be misleading.

In all of the numerous gymnosperms figured by Florin (11), with the exception of *Gnetum gnemonoides* Brongn., the guard cells are depressed below the general level of the outer surface of the epidermis and are more or less extensively *overtopped* by adjacent epidermal cells. On the contrary, the guard cells of *Tetracentron* and *Trochodendron* rest in a setting formed by the *subtending* parts of contiguous epidermal cells, *Figs. 13* and *14*. Furthermore, the outer vestibules of the stomata are formed by the cuticular covering of the guard cells rather than by that of neighboring cells, as in those gymnosperms which form such structures. The number, size, and form of the contiguous epidermal cells that are concerned in the formation of the setting for the guard cells fluctuates widely in both genera.

In *Tetracentron,* most of the subtending contiguous cells are of comparatively small size and appear to have been formed by appropriate anticlinal divisions of the larger surrounding epidermal cells, *Figs. 17–19*. Such an inference is strengthened by the not infrequent occurrence of large undivided epidermal cells having extensions which subtend the guard cells, (A) in *Figs. 17–19*. In this genus, the subtending cells usually are not concrescent at the center of the setting, leaving an irregularly shaped opening into the intercellular spaces of the mesophyll, *Figs. 13, 17–19*. At the focal level of the outer surface of the leaf, the narrow, curved, exposed parts of the smaller subtending cells resemble subsidiary cells oriented parallel to the outline of the guard cells. This deceptive similarity to "rubiaceous types" of stomata disappears, however, when adequately prepared material[3] is examined at successive focal levels, *Figs. 17–19*.

[3]Maceration and other techniques developed in connection with the study of cuticles and cuticularized residues of gymnosperms are unreliable in studying various types of angiospermic stomata. We have tested a wide variety of techniques in investigating the stomata of dried dicotyledonous leaves such as may be obtained from herbarium specimens. In dealing with *Tetracentron* and *Trochodendron* two types of preparations are essential. (1) Transverse sections of leaves prepared by soaking pieces of leaves in hot water, dehydrating, embedding in paraffin, serial sectioning, staining in Haidenhain's haematoxylin and sudan IV, and finally mounting the sections in glycerine. (2) Isolated sheets of the epidermis with more or less attached mesophyll for examining the stomata in surface view. Such sheets may be obtained in various ways, one of the most successful of which is the following. Small pieces of re-expanded leaves are attached by their lower surfaces to cover glasses, using Haupt's fixative hardened by formalin vapor. In the case of *Tetracentron,* most of the foliar tissue can then be peeled away, leaving the epidermis attached to the cover glass. In the case of *Trochodendron,* the overlying foliar tissues must be cut away under a dissecting microscope. The adhering epidermal strips are then stained with Delafield's haematoxylin and mounted in clarite. Microtome sections cut parallel to the lower surface of the leaf, obtained and treated as in (1), are also of value in interpreting surface views of the stomata.

The stomata of *Trochodendron* are of a fundamentally similar type, but differ in their more conspicuously developed cuticular vestibules, *Figs. 14–16,* their more extensively submerged contiguous cells, *Figs. 20–22,* and their much higher proportion of centrally concrescent subtending cells, *Figs. 15* and *16*. As indicated in *Figs. 20–22,* many of the subtending cells which form the setting for the guard cells become completely submerged by displacements during the ontogenetic development of the stomata. Thus, at the focal level of the outer surface of the leaf, the guard cells appear to be surrounded, at least in part, by ordinary epidermal cells "which are not of special form and orientation." Only where parts of the subtending cells are externally exposed does one encounter the appearance of narrow subsidiary cells oriented parallel to the outline of the guard cells, right side of *Fig. 21,* left side of *Fig. 22*. In *Figs. 14, 21,* and *22,* there is a narrow slit-like opening in the setting of the guard cells which communicates with the intercellular spaces of the mesophyll. In *Figs. 15* and *20*, the subtending cells are concrescent at the center of the setting and the passageway is closed. In *Fig. 16,* there is a broad cuticularized layer between the guard cells and their subtending, contiguous epidermal cells.

It seems likely that from a solely ontogenetic viewpoint of cell lineages, the stomata of *Tetracentron* and *Trochodendron* may be likened to Florin's haplocheilic gymnospermous type, but actually they are of a fundamentally different morphological form. Not until the stomata of a wide range of the Ranales and other orders have been carefully re-investigated will it be possible to assess the phylogenetic significance of different stomatal structures in discussions regarding the origin and the relationships of the dicotyledons.

It should be emphasized, in these connections, that the stomata and the vascular tissues of *Tetracentron, Trochodendron,* and the Winteraceae are of unusual interest from physiological as well as morphological points of view. They provide three distinctly different anatomical-physiological systems in vesselless plants with broad leaves that deserve intensive experimental investigation. The more or less conspicuously coriaceous leaves of the Winteraceae have stomata that are "plugged" by an alveolar modification of the cuticle. In these plants, there is an evident tendency to eliminate scalariform tracheary pitting. On the contrary, *Tetracentron* and *Trochodendron* have scalariformly pitted tracheids in the earlier-formed part of their growth layers. The coriaceous leaves of *Trochodendron* exhibit stomatal and other adaptations for retarding transpiration. The leaves of *Tetracentron* do not have such obvious morphological modifications for reducing water-loss, but there are conspicuous tracheary adaptations which appear to facilitate a more rapid flow of water from stems into leaves and from rootlets into roots.

## PALAEOBOTANICAL CONSIDERATIONS

Among the abundant, palmately veined, dicotyledonous leaves of Cretaceous and early Tertiary strata are many which were referred by the earlier palaeobotanists to such heterogeneous form genera as *Populus,*

*Populophyllum, Celastrophyllum,* etc. More recently Berry (7), and subsequently Seward and Conway (19), Sanborn (18), and others have recognized that the form and the venation of certain of these leaves so closely simulate those of *Cercidiphyllum* and *Tetracentron* as to indicate that they probably belong either to these genera or to closely related plants. The hypothesis that *Trochodendron* and *Tetracentron* or their allies were widely distributed in Holarctica during pre-glacial times is strongly supported by the occurrence of characteristic vesselless fossil wood in India, the northwestern United States, and East Greenland and of a fruit and seeds of *Trochodendron*-like type in the London Clays.

The re-examination of fossilized dicotyledonous floras to insure more accurate and reliable identifications of individual components of such floras is clearly a task for palaeobotanists, but the palaeobotanist must rely upon taxonomists and morphologists for basic data regarding extant dicotyledons and for clues concerning critical diagnostic criteria that may be preserved in fossilized material. It is advisable, accordingly, to summarize certain of our morphological observations for possible future palaeobotanical use, particularly as they are based upon the most extensive collections of *Trochodendron* and *Tetracentron* that have ever been assembled for investigation.

The leaves of *Trochodendron aralioides* Sieb. & Zucc., the only surviving species of the genus, are highly polymorphic, as illustrated in *Figs. 23–33.* Although certain of the diverse foliar forms may ultimately be shown to be correlated with specific geographical races or genetically significant varieties, the available evidence indicates that many, if not most of them, are due to ontogenetic and environmental influences and may occur on a single tree, either simultaneously or during successive stages of its growth to maturity. In any case, the polymorphism is so extensive that it should be reckoned with in any search for *Trochodendron* in fossil floras, as in the revision of heterogeneous form genera.

To insure a higher degree of diagnostic reliability, the student of dicotyledonous fossils must ultimately resort in many cases to techniques comparable to those which are being used so profitably in studying the foliar organic residues of gymnosperms and ferns. The chemically and mechanically most resistent, and therefore the structurally most persistent, parts of leaves commonly are the cuticularized and heavily lignified parts, i.e. the cuticle and epidermis, sclerenchyma, and xylem. The foliar cuticle of *Trochodendron* is very thick and forms distinctive stomatal vestibules, the sclerenchymatous elements are characteristically bizarre, and the vesselless xylem occurs in specific structural patterns within the petiole.

The palmately veined leaves of *Tetracentron sinense* Oliv. exhibit a much less extensive variability in external form than do the pinnately veined ones of *Trochodendron.* As indicated in *Figs. 34–39,* the leaves fluctuate somewhat in size, in breadth as related to length, in the degree of fineness of their serrations, in the contour of their bases and in their symmetry, but their range of variability does not overlap that of the conspicuously dimor-

phic foliage of *Cercidiphyllum japonicum* Sieb. & Zucc., which we shall discuss in a subsequent paper. Difficulties in differentiating the leaves of *Tetracentron* and *Cercidiphyllum* in fossil floras may be anticipated only upon the assumption that the ranges of morphological variability in hypothetical extinct species of the two genera tended to overlap. To clarify such putative uncertainties by resorting to microscopic analyses of foliar organic residues is likely to prove more difficult than in the case of the tough coriaceous foliage of *Trochodendron.* The leaves of *Tetracentron* and *Cercidiphyllum* are soft and delicate, having tenuous cuticles and no strikingly distinctive sclerenchymatous features. The highly characteristic secretory cells of the lamina of *Tetracentron* are unlikely to be preserved in recognizable form. A more profitable preliminary line of palaeobotanical endeavor in dealing with *Tetracentron* would appear to be a search for leaves with intact petioles or associated fragments of vesselless stems. As indicated earlier, the petioles of this genus are characterized by having extensive, bud-enclosing, stipular flanges, whereas the petioles of *Cercidiphyllum* are not. It is of interest in this connection that, according to Berry (7), many of the earliest known dicotyledonous leaves of late Lower Cretaceous horizons had petioles which enclosed the buds.

There is obviously no difficulty in differentiating the pinnately veined leaves of *Trochodendron* from the palmately veined ones of *Tetracentron.* Existing palaeobotanical uncertainties are due to superficial similarities in form and venation of the leaves of these genera and of other remotely related dicotyledons. On the contrary, the vesselless woods of *Trochodendron* and *Tetracentron* are remarkably similar, but are unlike the xylem of any other known representatives of the angiosperms. Thus, although the fossilized vesselless woods described by Sahni (17), Mathiesen (14), and Beck (6) should be compared to *Trochodendron* and *Tetracentron,* there is at present considerable uncertainty as to which genus they are more closely related. The most significant of these fossils is Sahni's *Homoxylon rajmahalense,* from the Rajmahal Hills of India, since it may prove to be of Jurassic age and would thus become the earliest known representative of the angiosperms. The specimen is a fragment of wood from a stem of relatively large size. There is no attached bark and the pith and earlier growth layers are not included. Sahni's description of the specimen is based largely upon comparison with *Trochodendron,* no wood of *Tetracentron* having been available for comparative purposes. The size, form, and description of the rays in *Homoxylon rajmahalense* are, however, of the type illustrated in *Fig. 9,* and are indicative of closer relationship to *Tetracentron* than to *Trochodendron.* It is essential that the specimen be reexamined to determine whether the wood parenchyma is likewise of the type which occurs in the former genus.

Beck's (6) specimen of vesselless wood from a Tertiary horizon of the northeastern United States resembles *Homoxylon rajmahalense* in its grosser features and in having rays that are suggestive of *Tetracentron* rather than of *Trochodendron.* The wood parenchyma of this specimen

also deserves detailed re-investigation. In the case of Mathiesen's (14) *Tetracentronites Hartzi,* from an Eocene horizon of East Greenland, both the rays and the wood parenchyma need to be re-examined for evidence of affinities to *Tetracentron* or *Trochodendron.*

It is unfortunate that none of these specimens of vesselless dicotyledonous wood include the pith, since the primary body, nodes, and first-formed secondary xylem of stems afford distinctive and reliable criteria for differentiating *Tetracentron* from *Trochodendron.* In dealing with fossilized dicotyledonous wood, it is essential for collectors to search for and to preserve both the earlier and the later-formed parts of stems. Similarly, in collecting such botanically significant leaves as those of *Trochodendroides,* a careful search should be made for fragments of small shoots which may occur within the same matrix. For, if they prove to be vesselless, they provide strong corroborative evidence for excluding *Populus, Cercidiphyllum, Grewia,* and other vessel-bearing genera whose leaves have at times been confused with those of *Tetracentron* or of *Trochodendron.*

It should be emphasized, in conclusion, that available palaeobotanical evidence, although fragmentary and uncertain in specific instances, indicates as a whole that *Tetracentron* and *Trochodendron* or closely allied plants have a very extensive geological record, extending backward to the late Lower Cretaceous, and possibly to the Jurassic in the Rajmahal horizon of India. These plants appear to have been widely distributed through Holarctica during pre-glacial times and only subsequently to have been confined to "relic" Asiatic areas.

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## EXPLANATION OF PLATES

### PLATE I

FIG. 1. *Tetracentron, H.U. 18052.* Transverse section of upper part of petiole, × 21. FIG. 2. *Tetracentron, H.U. 18050.* Transverse section of lower part of petiole, showing enclosed bud, × 25. FIG. 3. *Tetracentron, H.U. 18053.* Transverse section of stem at level of trilacunar node, × 25. FIG. 4. *Trochodendron, H.U. 18093.* Transverse section of upper part of petiole, × 27. FIG. 5. *Trochodendron, H.U. 18082.* Transverse section of basal part of petiole, × 21. FIG. 6. *Trochodendron, H.U. 18072.* Transverse section of stem at level of multilacunar node, × 11.

### PLATE II

FIG. 7. *Trochodendron, H.U. 8383.* Tangential longitudinal section of wood from a large stem, showing form and distribution of the rays, × 50. FIG. 8. *Tetracentron, H.U. 9695.* Transverse section of the wood, showing paired parenchymatous cells; the radially seriated derivatives of the cambium are oriented crosswise of the page, × 500. FIG. 9. *Tetracentron, Wilson 659.* Tangential longitudinal section of the cambium and inner phloem of bark from an old tree, showing form and distribution of rays, × 50.

### PLATE III

FIG. 10. Typical transverse planes of anticlinal division in the formation of the uniseriate wood-parenchyma strands of most gymnosperms and dicotyledons. FIG. 11. *Trochodendron.* Diagonal anticlinal divisions in the formation of the uniseriate wood-parenchyma strands. FIG. 12. *Tetracentron.* Longitudinal and diagonal planes of anticlinal division in the formation of biseriate wood-parenchyma strands. FIG. 13. *Tetracentron, Wilson 659.* Transverse section of a stoma, showing cuticular vestibule, guard cells, and subtending contiguous epidermal cells, approx. × 270. FIGS. 14–16. *Trochodendron. Jack,* in 1905. Transverse sections of stomata showing cuticular vestibule and three types of settings for the guard cells, approx. × 270.

### PLATE IV

Borders of the cuticular vestibule densely stippled. Guard cells less densely stippled. Exposed parts of contiguous epidermal cells lightly stippled. Submerged parts of contiguous cells indicated by broken lines.

FIG. 17. *Tetracentron, Wilson 659.* Surface view of stoma, showing guard cells with their partly subtending contiguous epidermal cells; (A) large subtending cells, approx. × 675. FIGS. 18, 19. *The same.* Less highly magnified surface views of stomata, showing various patterns of contiguous epidermals cells; (A) large subtending cells, approx. × 320. FIGS. 20–22. *Trochodendron, Jack,* in 1905. Surface views of stomata, showing varying degrees of submergence of the contiguous epidermal cells, approx. × 675.

### PLATE V

Leaves of *Trochodendron aralioides* Sieb. & Zucc., one-half natural size.

FIG. 23. *Takenouchi 1017.* FIG. 24. *Faurie 3643.* FIG. 25. *Wilson 9716.* FIG. 26. *Simada 876.* FIG. 27. *Sasaki 351.* FIG. 28. *Wilson 11231.* FIG. 29. *Mayr,* in 1886. FIG. 30. *Takenouchi 1017.* FIG. 31. *Gressitt 197.* FIG. 32. *Wilson 9716.* FIG. 33. *Jack,* in 1905.

### PLATE VI

Leaves of *Tetracentron sinense* Oliv., one-half natural size.

FIG. 34. *Henry 6243.* FIG. 35. *Tsai 57831.* FIG. 36. *Wilson 659a.* FIG. 37. *Cheng 3419.* FIG. 38. *Cheng 3419.* FIG. 39. *Wang 67836.*

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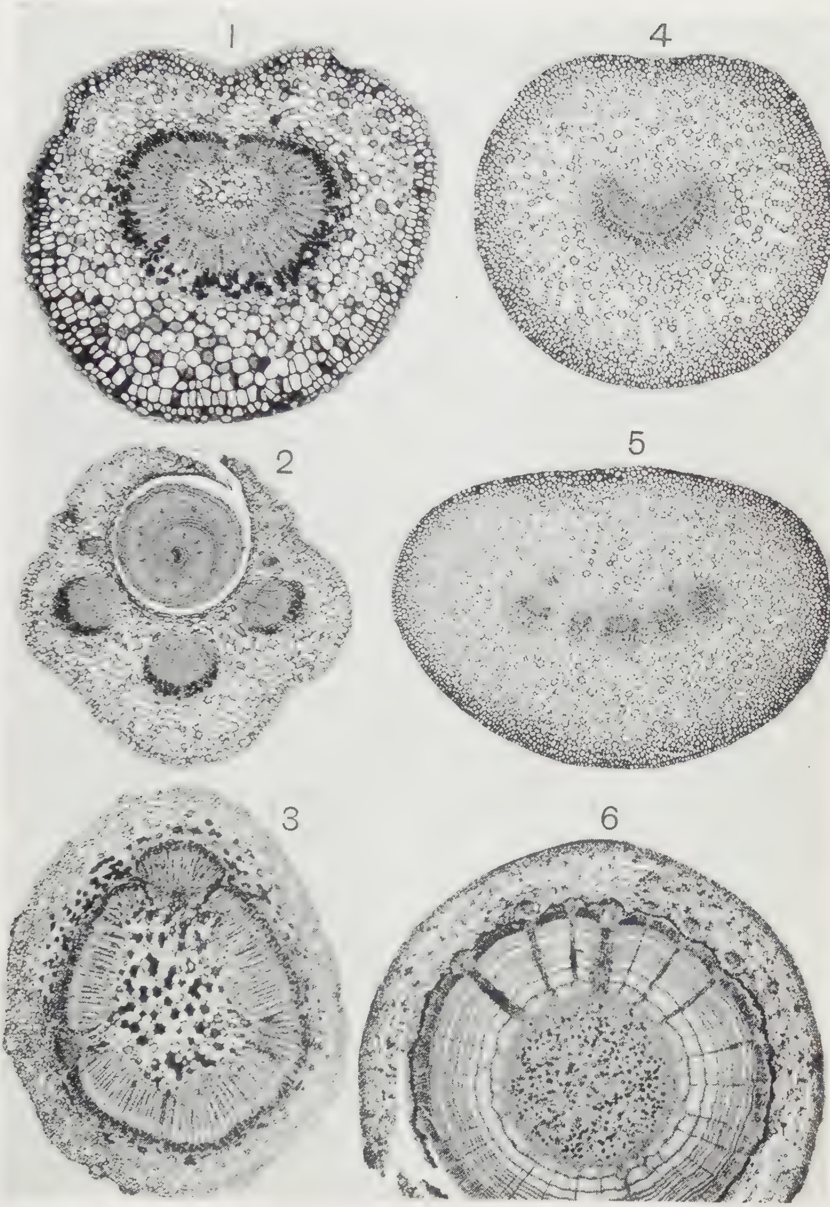
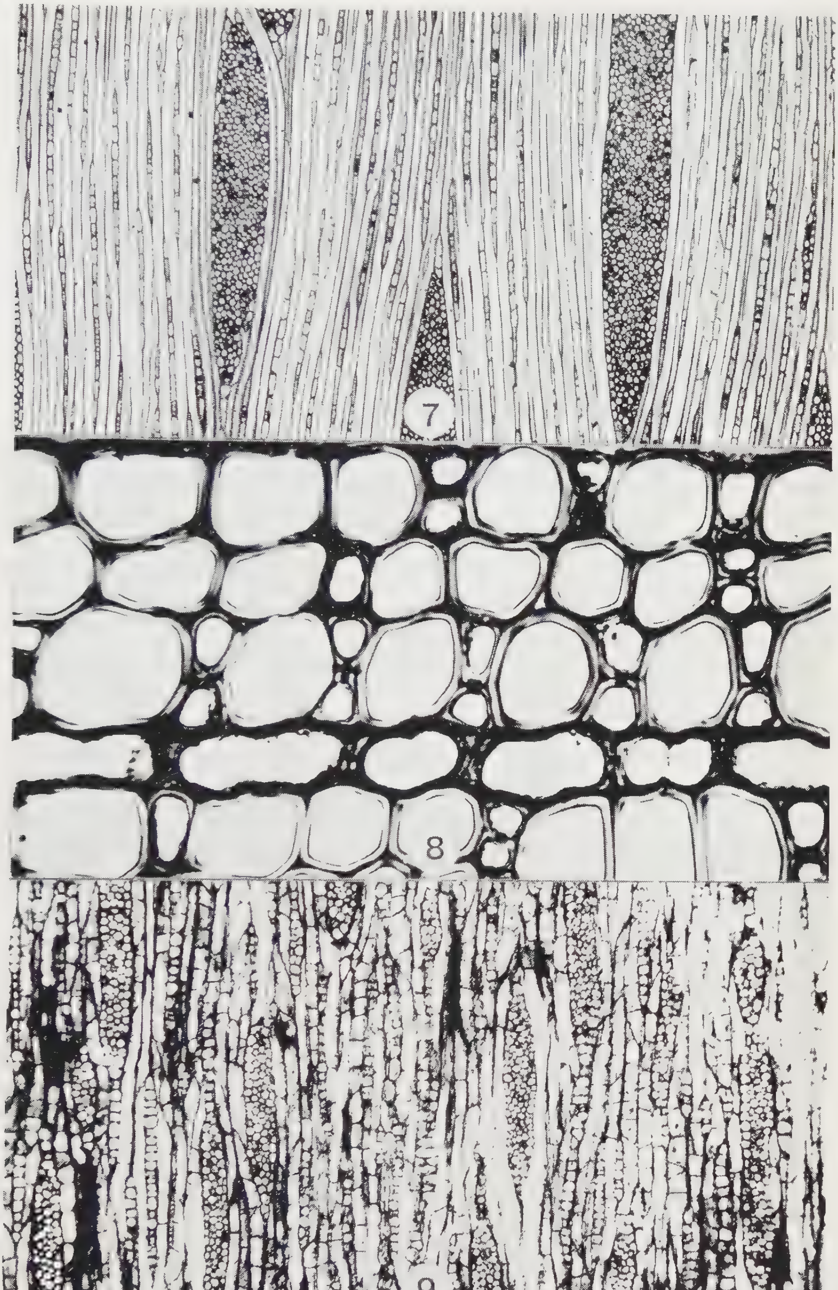



MORPHOLOGY OF TROCHODENDRON AND TETRACENTRON




Morphology of Trochodendron and Tetracentron


10


11


12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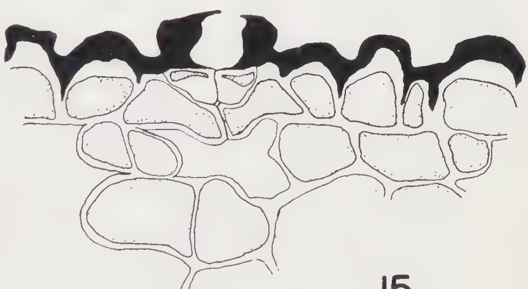
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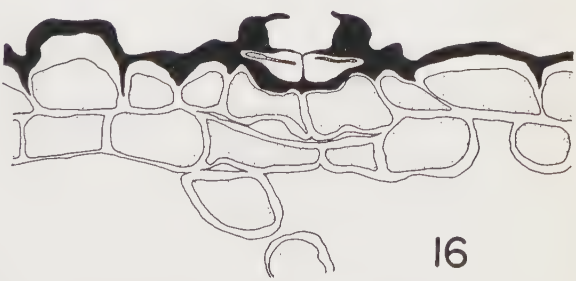
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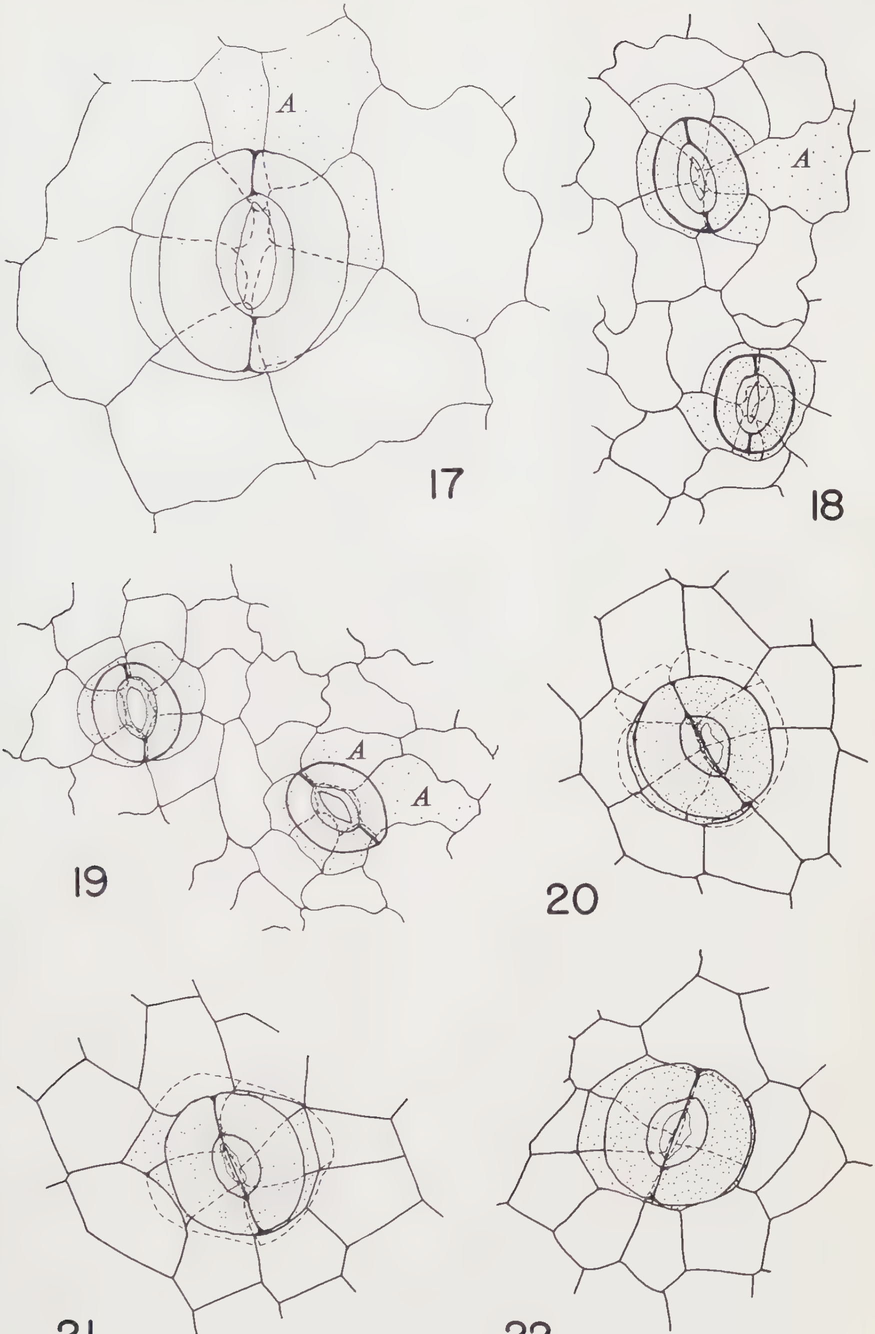
Morphology of Trochodendron and Tetracentron

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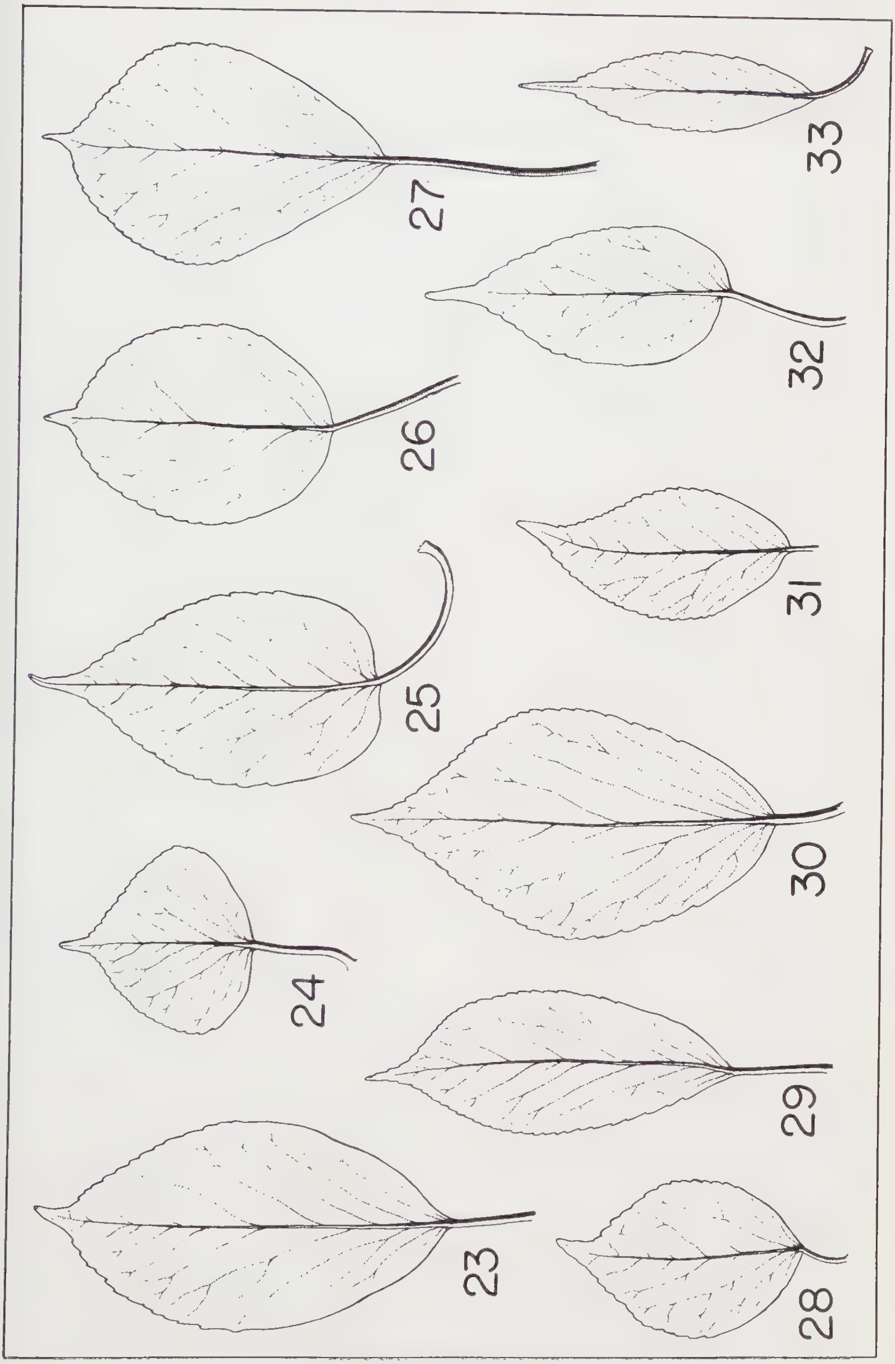


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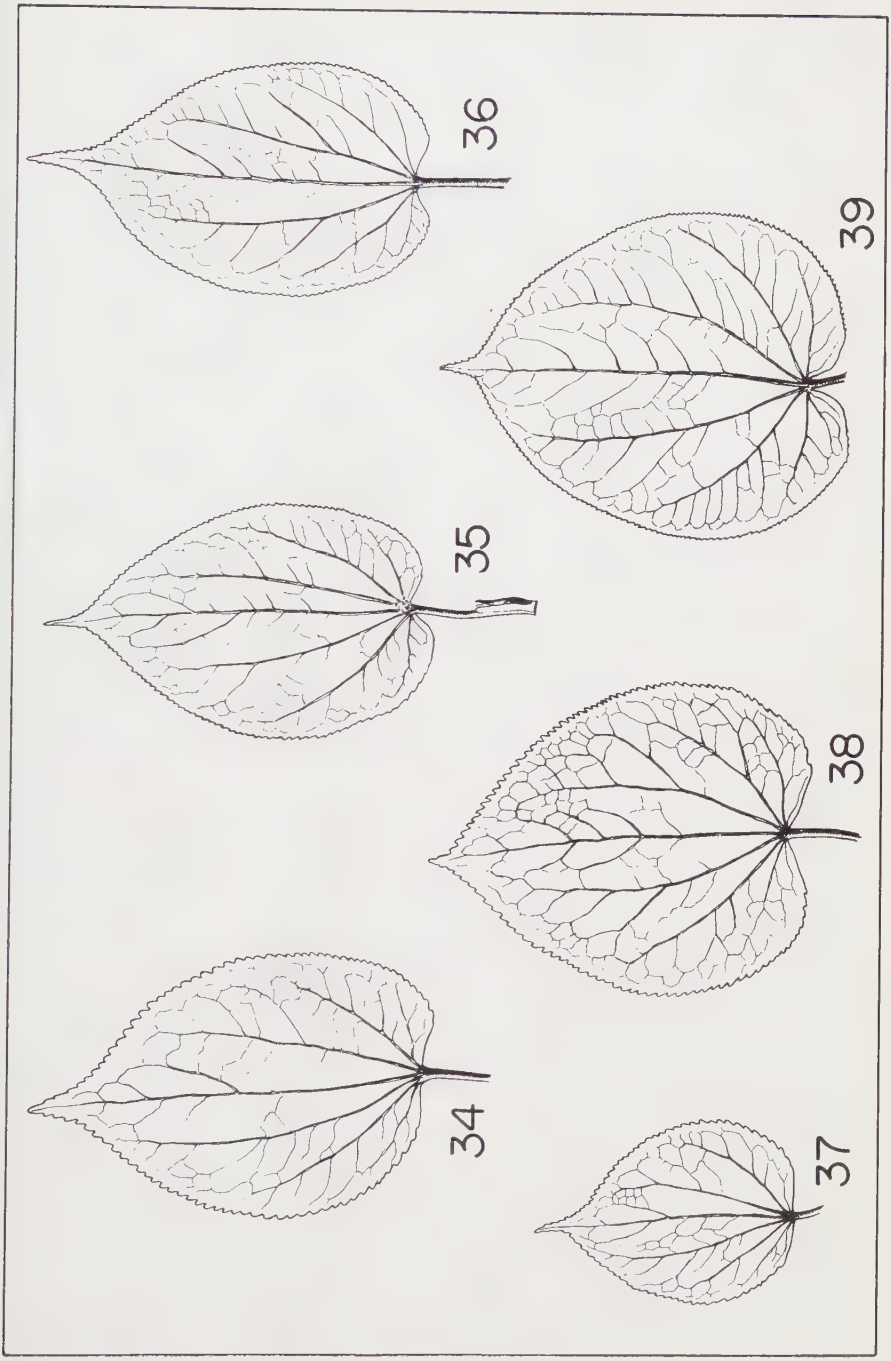


MORPHOLOGY OF TROCHODENDRON AND TETRACENTRON

# THE FOLIAR SCLEREIDS OF TROCHODENDRON ARALIOIDES SIEB. & ZUCC.

ADRIANCE S. FOSTER

*With four plates*

## INTRODUCTION

THE PRESENCE of branched sclereids in the parenchyma of the foliage leaf of *Trochodendron* has been regarded by Blenk (5), Matsuda (8), Parmentier (9, 10), Harms (7), van Tieghem (13), and Solereder (12) as one of the important diagnostic characters of this remarkable dicotyledon. As far as I have been able to determine, however, no study has been made either of the structure and development of the sclereids or of the possible fluctuations in their relative abundance, form, and distribution within the leaves of different individuals. Data on these points are essential in any effort to judge the systematic value of the sclereids in differentiating *Trochodendron* from other woody ranalian genera. In the present article, the results of a study of the form, structure, and distribution of sclereids in the mature foliage leaf of *Trochodendron* are presented. Living material, as well as leaves from 25 separate herbarium collections, has been investigated. A study of the ontogeny of the sclereids is now in progress and the results will be described separately in a future paper.

## MATERIAL AND METHODS

Abundant fresh material was secured, through the coöperation of Mr. Eric Walther, from a vigorous specimen of *Trochodendron* growing in the Strybing Arboretum of Golden Gate Park, San Francisco. Professor I. W. Bailey kindly furnished leaves from 20 herbarium collections representing, in equal number, specimens collected at various localities in Japan and Formosa. Acknowledgement is also due to Miss Alice Eastwood of the California Academy of Sciences, Dr. J. M. Greenman of the Missouri Botanical Garden, and Dr. H. L. Mason of the University of California for providing additional herbarium material from Japan. Specific reference to the various herbarium sheets is made in the text as well as in the explanatory legends accompanying the plates.

In order to study the form and distribution of the sclereids in the lamina of herbarium specimens, the general technique recently outlined by Bailey and Nast (1: 472–473) was employed. Sectors of the lamina, extending from the margin to the midrib, were first heated in water, then cleared in an electric oven in 5% NaOH, dehydrated in alcohol, and mounted from xylene without staining into balsam. Fresh material was similarly processed except that it was found desirable to extract first the chlorophyll in hot alcohol. For a more detailed examination of the form of the sclereids, portions of the lamina and petiole of fresh leaves were macerated by the

method already described in a recent article (Foster 6: 303–304). Serial sections of both the petiole and sectors of the lamina of fresh leaves were also studied and were prepared by the usual technique (Foster 6: 303).

Grateful acknowledgement is made to my wife, Helen Vincent Foster, for her skillful drawings of the sclereids illustrated in *Plates II-IV*, and to Professor I. W. Bailey for his helpful comments throughout the investigation.

## DISTRIBUTION OF THE SCLEREIDS

Before describing the remarkable polymorphism of the foliar sclereids, it is necessary to comment briefly on the general distribution of these cells in the adult foliage leaf. Serial sections as well as cleared leaf-sectors show that the sclereids typically occur as idioblasts dispersed through certain of the parenchymatous tissues of both petiole and lamina. In the petiole, the sclereids are most abundant in the inner extremely lacunate region of the cortex. Longisections indicate that, while the sclereids may occasionally appear in superposed groups of three or more connected cells, they are usually isolated from one another by parenchymatous elements. In the lamina, sclereids are found as idioblasts in the parenchyma tissue of the midrib and throughout the spongy mesophyll to within a few cells of the marginal epidermis. A careful study of cleared laminar sectors reveals considerable fluctuation in the relative abundance of sclereids. In many of the Japanese and Formosan collections, the profusely branched sclereids are so crowded as to suggest a loose "tissue" (*fig. 2*), while in other specimens, as for example G. G. P.[1], the sclereids tend to be more widely and evenly spaced within the vein-islets (*fig. 1*). Several of the Formosan collections appear unique because of the presence of small nests or clusters of irregular thick-walled sclereids above the juncture of the veins supplying each marginal tooth. This structural peculiarity is entirely wanting in the G. G. P. and the Japanese collections which have been studied and cannot be properly interpreted until a wider range of material is available for examination.

## FORM AND STRUCTURE OF THE LAMINAR SCLEREIDS

Previous descriptions of the sclereids of *Trochodendron* are both vague and inadequate and, as in the case of the sclereids of *Camellia japonica* (Foster, 6), a variety of terms has been applied to these cells, viz.: (1) "branched sclerenchyma cells" (Blenk, 5; Prantl, 11; Harms, 7; Solereder, 12); (2) "sclérites"[2] (van Tieghem, 13); (3) "internal hairs"[2] (Parmentier, 9, 10), and (4) "trichoblasts"[2] (Matsuda, 8). In none of these

[1]For brevity, the abbreviation "G.G.P." will be used throughout this paper to refer to the leaves of the specimen in Golden Gate Park, San Francisco.

[2]This term and others which have been applied to idioblastic sclereids in the seed plants have been discussed historically in a recent paper (Foster, 6). In that article (Table 1, p. 320) Seward is incorrectly cited as the originator of the term "sclérite." Further research shows that this term can be traced back through the French literature as far as the work of Bertrand (4). It has not been possible, however, to determine whether this author was the first to introduce the term into botanical literature.

papers, however, is any indication made of the remarkable polymorphism of the sclereids which is only fully revealed by the study of cleared sectors taken from comparable regions of the lamina of different individuals. By means of this relatively simple technique it becomes obvious that the laminar sclereids vary from radiately branched elements with dichotomous arms (*figs. 7–11*) to bizarre asymmetrical (*figs. 12, 13*), cruciform (*fig. 14*), and fiber-like forms (*figs. 15–22*). Intergradations of the most varied character occur between these form-types and preclude rigid demarcations. Nevertheless, when the *extremes* in sclereid-form are studied from the standpoint of their frequency and location within the lamina, certain interesting trends can be detected. The profusely ramified type of cell (*figs. 7–13*) appears to dominate throughout the submarginal portion of the laminae of all collections. In contrast, the strictly fusiform type of sclereid (*figs. 16–22*) attains the peak of development in the marginal portion[3] of the lamina and, moreover, is most consistently present in the leaves of the Formosan collections. Indeed, during the early phases of the investigation it seemed possible that the presence of large fiber-like marginal sclereids might represent a unique feature restricted to the leaves of Formosan plants. The examination of additional herbarium material from both Japan and Formosa, however, failed to reveal a sharp contrast with respect to this feature. For convenience, the fusiform and ramified types of sclereids will be described separately with special reference to (1) their occurrence within the various collections and (2) their form and structure.

1. *Fusiform types.* On the basis of the herbarium specimens available for study, it is clear that the fusiform or fiber-like type of sclereid is most abundant and reaches its greatest size[4] in the marginal region of the lamina of the Formosan collections (*figs. 2, 16–19*). Out of ten separate collections, only two failed to exhibit this character plainly. In contrast, the marginal sclereids in the collections from Japan tend to be profusely ramified and in many specimens differ from the submarginal sclereids merely in their larger size and more massive walls. Several of the Japanese collections were particularly notable for the complete absence of contrast, either in size or form, between the marginal and submarginal sclereids (e.g. *Wilson 6041*). Five out of the fifteen Japanese collections, however, were exceptional. One of the most striking of these was represented by the leaves of seedlings collected on Yakushima. In this material, long, slender, fusiform elements with abundant spicules are common in the marginal region of the lamina (*fig. 20*). Several other Japanese collections were likewise distinguished by the presence of fusiform marginal sclereids (*figs. 21, 22*). But in these specimens the sclereids are much shorter and less fiber-like than in the extreme examples provided by the Formosan material.

[3]By "marginal" is meant the narrow border of tissue between the small peripheral veins and the marginal epidermis. "Submarginal" designates the remaining portion of the lamina exclusive of the midrib (cf. *fig. 1* and *2*).

[4]The length of the fiber-like sclereids represented in *figures 16–19* are, respectively: 763, 795, 588, and 602 microns.

Structurally regarded, the fusiform type of marginal sclereid is very thick-walled with the lumen reduced to a narrow channel except in the median region of the cell. In certain of the Formosan collections (*Henry 1398, Simada 350, Tanaka 5412*) many of the fiber-like sclereids are relatively smooth-walled except near the mid-region (*figs. 16–18*). More commonly, however, the sclereid is provided with very numerous sharp-pointed spicules or blunt, knob-like processes (*figs. 2, 19, 21, 22*). This condition closely resembles the situation in the large fusiform petiolar sclereids of *Camellia japonica* (Foster 6, *pl. 2* and *3*). In contrast, however, to the extremely numerous and often ramiform pit-canals typical of the sclereids of *Camellia,* pits are relatively few and apparently are restricted to the central portion of the fusiform sclereids in *Trochodendron.* A full discussion of their structure and development will be presented in a future paper.

2. *Ramified types.* As stated earlier in this paper, the ramified type of sclereid predominates throughout the submarginal region of the lamina of all collections (*figs. 1, 2*). Branched sclereids, which fluctuate greatly in size, also occur interspersed among the huge fiber-shaped marginal sclereids of the Formosan collections (*fig. 2*). In this material, transitions between fusiform and branched types are abundant and often are extremely irregular and grotesque in character (*fig. 18*).

As is clearly shown in *Plate III,* the branched sclereids vary widely in their form. In certain of the collections from Japan as well as Formosa a series of repeatedly dichotomizing branches radiates in a more or less symmetrical fashion from the central body of the sclereid (*figs. 7, 9*). More commonly, however, the branched sclereids are asymmetrical because of the unequal development of one or more of the arms (*figs. 1, 2, 8, 10–13*). There is, of course, no sharp boundary between the symmetrical and asymmetrical types of branching and both conditions may intergrade within the same leaf. The forms depicted in *Plate III* were deliberately selected to show some of the extremes. In one collection from Japan an amazing degree of polymorphism was discovered, the sclereids ranging in form from profusely branched elements to cruciform and short, irregular, fiber-like types (*figs. 14, 15*). In no other specimen investigated were submarginal sclereids, comparable to the cell shown in *figure 15,* encountered.

As to structure, the ramified sclereids typically are thick-walled cells with correspondingly narrow lumina (*figs. 8–13*). Exceptions to this condition, however, occur in two collections, one from Japan (*Siebold*) and one from Formosa (*Tanaka 5412*). In these specimens, *all* of the submarginal sclereids are relatively thin-walled and possess very slender arms (*fig. 7*). Some of the Japanese collections exhibit an extreme condition with respect to the thickness of the sclereid-wall. In these cases, a "stratum" of very thin-walled sclereids occurs just beneath the abaxial epidermis. Many of these cells are trilobate in surface view and differ from the neighboring parenchyma elements principally by the presence of very short, spicule-like arms. The latter may occur in pairs at each corner or may be unequal in number and vestigial in appearance. Such sclereids, in a certain sense,

seem to represent transitions between parenchyma cells and the more elaborately branched, thicker-walled sclereids which occur at deeper levels in the mesophyll. The relative abundance of spicules on the ramified types of sclereids fluctuates widely. For example, spicules appear consistently on all the sclereids of the G. G. P. specimen, their abundance varying with the size and form of the cell (*figs. 1, 5, 6, 8*). Spicules are likewise prominent in one of the collections from Yakushima, Japan (*fig. 13*). Beginning with these extremes, various conditions of decreasing prominence of spicules were noted in the collections culminating in such smooth-walled types as is illustrated in *figure 7*. As in the case of the fiber-like marginal sclereids, pits are few in number and are confined to the median region of the cell.

## FORM AND STRUCTURE OF THE PETIOLAR SCLEREIDS

As stated previously, sclereids are largely confined to the inner highly lacunate cortical parenchyma of the petiole. The examination of partially macerated tissue, supplemented by serial longisections, of the G. G. P. specimen reveals extensive fluctuations in the form of the petiolar sclereids. In no instance, however, have symmetrical radiately branched elements comparable to those found in the submarginal portion of the lamina been observed. Very commonly, the petiolar sclereids are roughly H-shaped, with paired, acuminate vertical arms (*fig. 3*). The latter lie freely within the longitudinally extended air-spaces in the parenchyma. In elements of this type, one or more uncinate lateral branches are often present. Further complexity results in many cases from the development of additional vertical arms (*fig. 4*). Sclereids of this kind likewise are scattered within the parenchyma tissue of the midrib. Many of the petiolar sclereids, however, are more irregular in form, with their various branches unequal in length and radiating in the most varied directions from the central body. As shown in *figures 3* and *4* spicules, varying in size and distribution, occur in the petiolar sclereids.

Because of the great difficulties involved in the study of cleared portions of the petiole, it has not been possible to determine fully the distribution of the various form-types in the herbarium collections. However, in several of the Formosan collections (*Simada 350* and *Wilson 11231*) magnificent examples of fiber-like sclereids occur in addition to H-shaped and irregularly branched types. Two of the longest of the fusiform types measured respectively 1002 and 1465 microns in length. Such extremely long sclereids are of particular interest because of the presence of similar but shorter cells in the marginal region of the lamina of the same specimens (cf. *figs. 17* and *19*). Whether typical fiber-like sclereids ever occur in the petiole of the Japanese material remains to be determined. As far as the present study goes, there is no evidence of them.

## DISCUSSION AND CONCLUSIONS

The present study of the foliar sclereids in *Trochodendron* provides an excellent illustration of the range in form, size, and structure possible within

the limits of one morphological "cell-type." Because of the abundance of intergradations it is obvious that no sharp boundaries exist between the various form-types. Thus, in the lamina, the profusely branched and fiber-like forms are clearly the extremes in cell specialization at the two ends of a continuous morphological series (*Plates III* and *IV*). Similarly, in the petiole, the H-shaped and fusiform types cannot be rigidly demarcated from the more irregularly branched forms.

From these facts it is clear that the entire gamut of form-types must be fully recognized if the sclereids are to be used as one of the diagnostic criteria of *Trochodendron*. This is particularly evident when the fluctuations in the occurrence of the fiber-like type of sclereid are taken into consideration. In the majority of the Japanese collections, strictly fusiform, unbranched sclereids are absent from both the marginal and submarginal portions of the lamina. Conversely, the majority of the Formosan specimens are distinguished by the high proportion of elongated, relatively unbranched, marginal sclereids (*figs. 2, 16, 17, 19*).

Admittedly, however, the present investigation has merely uncovered what appears to be a *general trend* in the distribution of the fiber-like type of foliar sclereid. Obviously a wide range of leaf-types, collected from different regions of the same plant as well as from individuals growing under various ecological conditions in both Japan and Formosa, should be compared. Nevertheless, in the material examined, there appears to be no correlation between the size or form of the lamina and the presence or absence of fiber-like marginal sclereids. This is most convincingly shown in the case of the living specimen in Golden Gate Park. Here it was possible to examine a wide series of leaf-types, including the minute laminae of the transition forms between bud-scales and foliage leaves. In all instances, the marginal region of the lamina is devoid of the very elongate, fiber-like sclereids typical of most of the Formosan collections (compare *figs. 1* and *2*). The herbarium material was necessarily very limited and consisted of one or two leaves from each collection. Nevertheless the size and form of the leaf varied and, in the specimens furnished by Professor Bailey, included laminae which were lanceolate, ovate, and rhomboid in contour (cf. Bailey and Nast, 3: *Pl. V*). In all of this material, the occurrence of fiber-like marginal sclereids varied independently of either the size or form of the leaf-blade.

In their recent survey of the leaves of the Winteraceae, Bailey and Nast (2) have shown that the trends of sclerification include armed sclereids as well as nests of sclereids, lignified thickenings of the mesophyll, and sclerenchymatous vein-jackets. In *Trochodendron*, whose systematic relationships with other ranalian groups remains to be clarified, the foliar sclereids appear to exhibit two major trends in specialization, viz.: (1) the slender, radiately branched types (*figs. 7–11*) and (2) the massive fiber-like forms (*figs. 16–22*). The phylogenetic and systematic implications of this polymorphism will not become apparent, however, until the foliar sclerenchyma of other ranalian genera has been fully studied.

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## EXPLANATION OF PLATES

### PLATE I

Laminar sectors cleared in NaOH and photographed unstained in balsam. In each figure, the margin is toward the upper edge of the plate. Magnification × 93.

FIG. 1. Golden Gate Park material, showing irregularly branched sclereids. Note the large size and muricate surface of certain of the marginal sclereids. FIG. 2. *Simada 876,* Formosa, showing the closely packed fiber-like marginal sclereids. Note variations in size and type of branching of the submarginal sclereids.

### PLATE II

Camera-lucida drawings of sclereids isolated by maceration from leaves of the Golden Gate Park specimen. In order to show the distribution of the spicules, the narrow branched lumen of these cells has been omitted in the drawings. Magnification × 240.

FIG. 3. Slender H-shaped sclereid from the petiole. Note the short uncinate branches of this cell. FIG. 4. Sclereid from the petiole with three systems of vertical branches. Note intergradations between spicules and short lateral branches. FIG. 5. Radiately branched sclereid from the submarginal region of the lamina. FIG. 6. Large, irregularly branched, muricate sclereid from the marginal region of the lamina. Elements of this type are also shown *in situ* in *Plate I, fig. 1.*

### PLATE III

Camera-lucida drawings of sclereids from the submarginal region of cleared sectors of the lamina. Each cell is shown as it appears in median optical view; the central portion of the lumen is indicated by the broken outline. *Figs. 7–11,* radiately branched types; *figs. 12, 13,* irregularly branched types; *fig. 14,* cruciform type; *fig. 15,* irregular fiber-like type. Magnification × 180.

FIG. 7. *Siebold* (type coll.), Japan. FIG. 8. *Golden Gate Park* specimen. FIG. 9. *Wilson 11231,* Formosa. FIG. 10. *Wilson 11231,* Formosa. FIG. 11. *Sasaki 351,* Formosa. FIG. 12. *Henry 1398,* Formosa. FIG. 13. *Wilson 6041,* Yakushima, Japan. FIG. 14. *U.S.N.H. 350937,* Japan (*Collector?,* May 25, 1897, Amagi-san). FIG. 15. *U.S.N.H. 350937,* Japan (*Collector?,* May 25, 1897, Amagi-san).

### PLATE IV

Camera-lucida drawings of fiber-like sclereids from the marginal region of cleared sectors of the lamina. Each cell drawn in median optical view; dotted outline indicates central portion of lumen. Magnification × 180.

FIG. 16. *Henry 1398,* Formosa. Long, slender, fiber-shaped sclereid. Note relatively smooth wall. FIG. 17. *Simada 350,* Formosa. Note short, irregular branches near central region of cell. FIG. 18. *Tanaka 5412,* Formosa. Irregular, fiber-like sclereid. This cell illustrates the common intergradation in form between strictly fusiform and branched sclereid-types. FIG. 19. *Wilson 11231,* Formosa. Very broad, fusiform type, prominently muricate. Consistently present in this collection. FIG. 20. *Wilson 6041,* Yakushima, Japan. Fiber-like type, with abundant spicules. FIG. 21. *Jack,* Oct. 25, 1905, Japan. Short, fusiform type. Abundant in this collection. FIG. 22. *U.S.N.H. 350937* (*Collector?,* May 25, 1897, Amagi-san). Short, irregularly branched type, closely resembling *fig. 21.*

UNIVERSITY OF CALIFORNIA,
BERKELEY.

Foliar Sclereids of Trochodendron

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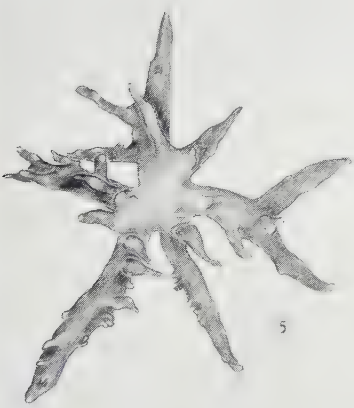

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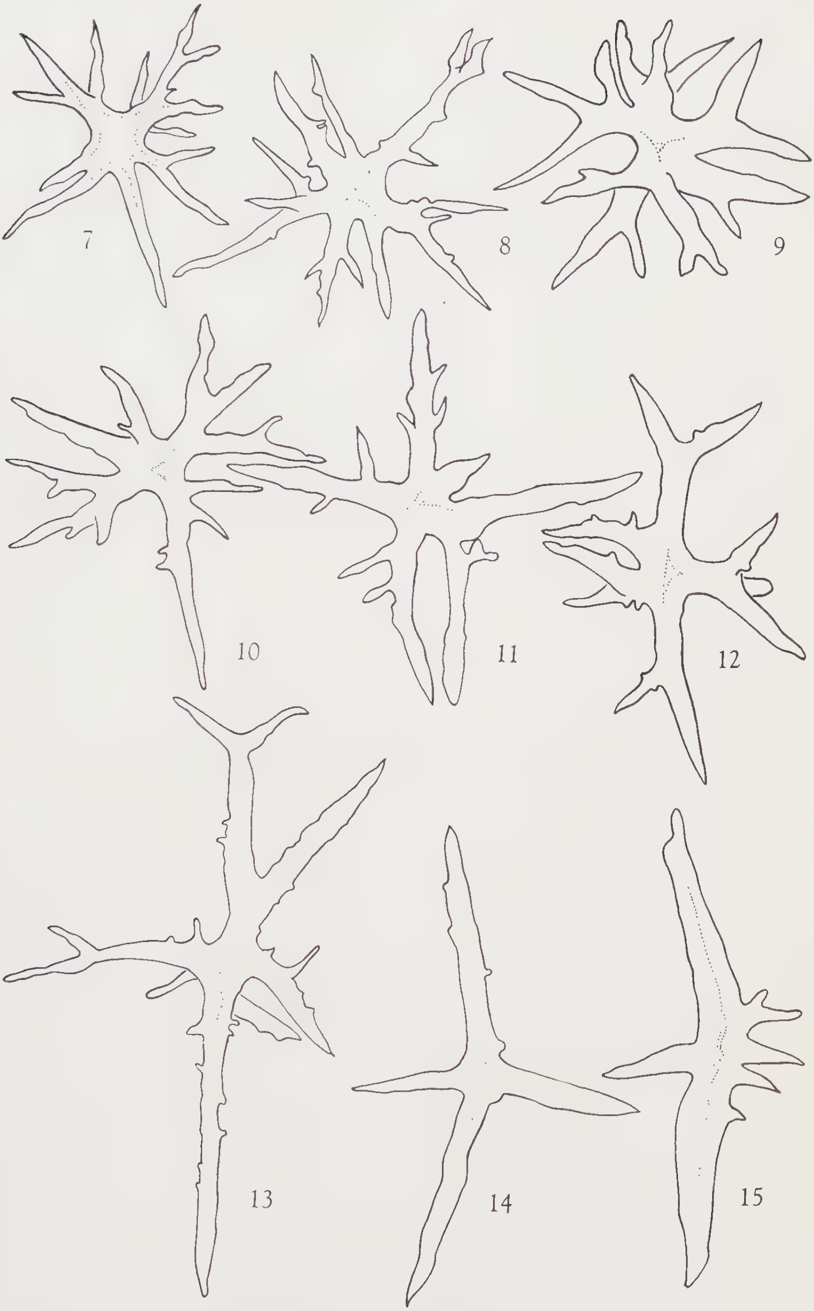
Foliar Sclereids of Trochodendron




Foliar Sclereids of Trochodendron


FOLIAR SCLEREIDS OF TROCHODENDRON

# TWO NEW SPECIES FROM THE VICINITY OF HONGKONG

E. D. MERRILL

*With three text-figures*

IN THE course of identifying a collection of plants made by Mr. Y. W. Taam at Hongkong, Lantao Island, and Hongkong, New Territory, I was rather surprised to note several apparently undescribed species from a limited area that has been intensively explored from a botanical standpoint for more than a century. The material studied represents approximately 575 numbers, and it was submitted to me by Prof. H. H. Bartlett of the University of Michigan, who financed the field work. The material was well selected and well prepared.

Two novelties are described in this paper. In addition to these, one species previously described from outside of China is recorded for the first time from that country. A third species illustrated is what I take to be the little known *Maackia australis* (Dunn) Takeda. Incidentally, the collection contains a number of species previously described from various parts of Kwangtung Province but which hitherto have not been recorded from Hongkong and Lantao Islands or from Hongkong, New Territory. Naturally, the collection made in what is a most important classical region contains a great many topotypes — that is, specimens collected from approximately the same localities as were those on which many scores of descriptions of new species were based. Fortunately it was possible for Mr. Taam to ship his material to the United States before the Japanese occupation of Hongkong took place. In addition to the few records included in this paper, his material showed clearly that the Kwangtung-Hongkong form long passing as *Hippocratea obtusifolia* Roxb., the type of which was from India, is actually rather remote from that species, and elsewhere in this Journal (p. 170) Dr. A. C. Smith has described this as a new species of *Loeseneriella*.

## ORCHIDACEAE

### Eulophia R. Brown

**Eulophia macrorhiza** Blume, Fl. Jav. Orch. 155 (Orch. Archipel. Ind. 183). *t. 63, f. 2, t. 66B.* 1858.

HONGKONG: Lantao Island, near Tungchung, rare in thickets, *Y. W. Taam 2092,* June 3, 1941, det. C. Schweinfurth. A variable species extending from Java to Celebes, New Guinea, and the Philippines (Luzon, Leyte); new to the area and to China.

## LEGUMINOSAE

### Maackia Ruprecht & Maximowicz

**Maackia ellipticocarpa** sp. nov. FIG. 1.

Frutex circiter 2 m. altus, inflorescentiis exceptis glaber vel subglaber (floribus ignotis); ramis teretibus levibus, atro-purpureis vel olivaceo-purpureis, conspersissime lenticellatis, ramulis ultimis glabris, 2 mm.

diametro; foliis 9–15 cm. longis, foliolis 7–9, ovatis vel elliptico-ovatis, plerumque acutis vel leviter acuminatis basi plerumque rotundatis, interdum obtusis, subcoriaceis, 2–4.5 cm. longis, 1.2–2.5 cm. latis, olivaceis, subopacis, subtus paullo pallidioribus, utrinque glaberrimis, nervis primariis utrinsecus circiter 6, arcuato-anastomosantibus, subtus elevatis, distinctis, reticulis ultimis subconfertis; petiolulis leviter incrassatis, 1–1.5 mm. longis; inflorescentiis terminalibus, sub fructu ad 12 cm. longis, ramis primariis 2 vel 3, racemiformibus, partibus junioribus obscure breviter pubescentibus glabrescentibus; pedicellis 5 mm. longis, obscure breviter adpresse pubescentibus, vetustioribus glabrescentibus; fructibus ellipticis vel oblongo-ellipticis, compressis, 2–3.5 cm. longis, 1–1.5 cm. latis, valvis


FIG. 1. *Maackia ellipticocarpa* Merrill: *a*. a fruiting branchlet, × ½; *b*. a pod with seeds, × ½.

glabris vel deorsum leviter adpresse pubescentibus, distincte consperseque glandulosis, utrinque rotundatis vel basi interdum late acutis vel obtusis, irregulariter subtransverse reticulato-venosis, suturis superioribus anguste carinatis, haud alatis; seminibus 1–3, ad 7 mm. longis.

HONGKONG: Lantao Island, near Tungchung, *Y. W. Taam 1693*, Sept. 12, 1940, abundant on dry clay slopes near the seashore, among scattered shrubs.

This species is clearly allied to *Maackia Tashiroi* (Yatabe) Makino, of southern Japan and the Liu Kiu Islands, differing in its fewer leaflets and its distinctly glandular fruit-valves. The original illustration of *Cladrastis Tashiroi* Yatabe, Bot. Mag. Tokyo 6: 345. *t. 10*. 1892, is excellent, and we fortunately have a fine series of specimens from Oshima representing the species, these with both flowers and fruits. The number of leaflets on this

material varies from 9 to 15 on each leaf. Makino, Notes Bot. Gard. Edinb. 8: 102. 1913, has explained the confusion regarding *Derris chinensis* Benth., the fruiting specimen of which, from Oshima, actually represents *Maackia Tashiroi* (Yatabe) Makino, while the Hongkong flowering specimen represents *Millettia pulchra* Benth.

**Maackia australis** (Dunn) Takeda, Notes Bot. Gard. Edinb. **8**: 102. *t. 27, f. 57–62.* 1913. FIG. 2.

*Cladrastis australis* Dunn, Kew Bull. Add. Series **10**: 86. 1912.

HONGKONG: Lantao Island, *Y. W. Taam 2134,* June 7, 1941, a shrub 2 m. high, abundant on damp slopes among scattered shrubs, flowers white, odorless.


FIG. 2. *Maackia australis* (Dunn) Takeda: *a.* a flowering branch, × ½; *b.* calyx, ovary, and style; *c.* ovary and style; *d.* calyx, spread, showing the three small lobes and the fourth larger one; *e.* keel petals; *f.* a wing petal; *g.* standard; *b-g* all enlarged.

When this specimen was first studied it was thought to represent a distinct species, because of certain discrepancies between its characters and those of *Cladrastis australis* Dunn as indicated in the original description of the latter, and in Takeda's consideration of it. In this Taam specimen the standard is oblong or narrowly oblong-obovate, not ovate as in Dunn's description, and the leaflets have 7 or 8 pairs of lateral nerves rather than 5. Dunn described the leaflets of his species as "in apicem obtusum angustata," but Takeda, on the basis of the same material that Dunn had, says that they are mucronulate, and his figure, *t. 27, f. 61,* shows them to be very slenderly and sharply acuminate. His figure of the standard, *t. 27, f. 60,*

shows it to be very narrowly oblong-obovate (not ovate as Dunn says), the slender nerves extending to the base, the basal parts not thickened and nerveless or nearly so as in the Taam collection. A re-examination of the type specimen and a comparison of the Taam material with it is desirable, as it may reasonably be expected that there are certain errors in the original description, or possibly representatives of more than a single species were included.

Dunn's description was based on a collection made on the North West River in Kwangtung Province, and a Millet collection, "*Sophora* from China, Hort. Soc. Hort. Lond. 1838," indicating that the species was cultivated in England at that date. It is by no means impossible that this Millet specimen was grown from seeds collected by him on Lantao Island. Takeda says that the Millet specimen in the Kew Herbarium bears the date 1835. Certainly at the date indicated there was no possibility of the Millet collection having been made on the North West River in Kwangtung Province.

## EBENACEAE

### **Diospyros** Linnaeus

**Diospyros Taamii** sp. nov. FIG. 3.

Arbor parva, circiter 7 m. alta, partibus junioribus fructibusque exceptis glabra; ramis teretibus, glabris, in sicco longitudinaliter subrugosis, ramulis


FIG. 3. *Diospyros Taamii* Merrill: *a*. a fruiting branch, $\times \frac{1}{2}$; *b*. a leaf, with a portion enlarged to show the ultimate reticulations; *c*. an immature fruit, $\times 1\frac{1}{2}$; *d*. cross-section of an immature fruit, showing the persistent sepals; *e*. an individual sepal, dorsal view; *f*. dorsal view of a fruiting calyx; all somewhat enlarged.

ultimis gracilibus, glabris, 1 mm. diametro; foliis firmiter chartaceis vel subcoriaceis, utrinque glabris, in sicco pallidis, oblongis vel oblongo-ellipticis, 6–10 cm. longis, 2–4 cm. latis, sursum angustatis, distincte sed obtuse acuminatis, basi subrotundatis vel late acutis, nervis primariis utrinsecus 5 vel 6, supra obscuris, subtus distinctis, elevatis, curvato-adscendentibus, arcuato-anastomosantibus, utrinque sat dense reticulatis sed vix foveolatis; petiolo 6–8 mm. longo, glabro; floribus ignotis; fructibus in ramulis ultimis solitariis vel 2 vel 3 in ramulis specialibus racemosim dispositis, his plus minusve subadpresse hirsutis et aliquando foliiferis, fructibus globosis, immaturis circiter 1 cm. diametro, 8-locellatis, densissime adpresse breviter pallide pubescentibus; sepalis persistentibus coriaceis, ovatis, circiter 1 cm. longis et 8 mm. latis, sursum leviter angustatis, rotundatis, utrinque dense subreticulato-venosis, venis venulisque subelevatis, extus consperse hirsutis, pilis longis, adpressis, pallidis.

HONGKONG: Lantao Island, Tai Shan, *Y. W. Taam 2169*, June 12, 1941, abundant on moist slopes in thickets.

With fruiting material alone available it is difficult to place this rather strongly marked species in its proper group. It seems to be allied to *Diospyros Tutcheri* Dunn, but in that species the fruits are described as glabrous.

ARNOLD ARBORETUM,
HARVARD UNIVERSITY.

# DAVID DON'S "PRODROMUS FLORAE NEPALENSIS"

WILLIAM T. STEARN

THE "Prodromus Florae Nepalensis, sive Enumeratio Vegetabilium quas in Itinere per Nepaliam proprie dictam et Regiones conterminas, ann. 1802–1803, detexit atque legit D. D. Franciscus Hamilton, (olim Buchanan)" by David Don (1799–1841) is an unpretentious little book of considerable importance to students of the Himalayan flora,[1] for many species were first described in its 256 pages. It evidently took a long time to prepare. A letter to Wallich from Buchanan-Hamilton dated 16 October 1821 states that "A Mr. Don, however, who lives with Mr. Lambert, to whom I gave duplicates of the collection presented to Sir J. E. Smith, is engaged in publishing an account of them together with those which you have sent, and I believe he has both abilities and industry to produce a very valuable work." (Ann. Roy. Bot. Gard. Calcutta 10[2]: xxxi. 1905). Don's preface is dated "Kalendis Octobris, Ann. 1824" and in Trans. Linn. Soc. London 18: 518 (1841) he states that it was "completed and some copies of the work distributed before the close of 1824." As the title-page is dated "MDCCCXXV," it was evidently not intended or expected to be available to the public until 1825, and the Monthly Literary Advertiser, no. 240, p. 28, 32 (9 April 1825) lists it among the new books published in March 1825. A copy once belonging to John Lindley (1799–1865), who published, in the Botanical Register 11: sub *t. 872* (1 March 1825), a scathing review of Don's work, is in the Lindley Library of the Royal Horticultural Society. On the title-page Lindley has written "Published 1 Feb. 1825," and there seems no reason to question this statement. Hence *February 1825 may be taken as the date of publication of D. Don's "Prodromus Florae Nepalensis."* The names published in it thus have priority over names published in A. P. DeCandolle's "Prodromus Systematis Regni Vegetabilis" vol. 2 (Nov. 1825; cf. Stearn in Candollea 8: 1–4. 1939).

LINDLEY LIBRARY,
ROYAL HORTICULTURAL SOCIETY,
LONDON, ENGLAND.

[1]For dates of publication of another important work on Himalayan plants, Royle's "Illustrations of the Botany . . . of the Himalayan Mountains" (1833–1840), see Sprague in Kew Bull. 1933: 378–390 (1933), Stearn in Jour. Arnold Arb. 24: 484–487 (1943).

# NOTES ON HIPPOCRATEACEAE IN SOUTHEASTERN ASIA

A. C. Smith

*With three text-figures*

In attempting to identify a specimen of Hippocrateaceae recently collected in Hongkong, it became necessary to look into the typification of *Hippocratea obtusifolia* Roxb., a name which has in the past accommodated many of the capsular-fruited large-disked specimens of the family from southeastern Asia. In the course of this study the available material from India, Burma, Indo-China, and China was examined, and it became apparent that two undescribed Chinese species had been passing as *H. obtusifolia.* Descriptions of these and notes on several other species follow, new combinations in the genera *Loeseneriella* and *Pristimera* being proposed for some of them. Specimens are cited from the following herbaria: Arnold Arboretum (A), Gray Herbarium (GH), New York Botanical Garden (NY).

## Loeseneriella A. C. Sm.

**Loeseneriella obtusifolia** (Roxb.) A. C. Sm. in Am. Jour. Bot. 28: 440. 1941.
*Hippocratea obtusifolia* Roxb. Fl. Ind. 1: 170. 1820.
*Hippocratea tortuosa* Wall. Cat. no. 4216, nomen. 1830.

*Hippocratea obtusifolia* is based upon a plant collected on the Coromandel coast of India. The species has been accredited with a very wide distribution and has become, in herbarium usage, a collective concept. Careful examination of the pertinent early literature and the available historical specimens is essential for a proper understanding of Roxburgh's species. In this connection, several available specimens fortunately permit a clear understanding of it.

A specimen labeled "*Hippocratea obtusifolia* Roxb. Hort. bot. Calcutt." (GH), in flower, agrees very well with the original description. It is apparent that Roxburgh had this species in cultivation at Calcutta, from his comment: "Flowering time in the Botanic Garden, March and April; the seeds take one year to ripen." There appears to be little doubt that the specimen at hand was collected from the original plant and that it may be taken essentially as an isotype.

A second specimen, labeled "*Hippocratea obtusifolia* R. in fruit. BGC. 6 Augt. 1889" (GH), is also apparently taken from the same plant in the Calcutta Botanic Garden.

A third important collection is *Wight 465* (GH, NY), in flower, almost certainly a duplicate of the specimen which served as the basis of Wight's much-cited plate of *Hippocratea obtusifolia* (Ic. Pl. Ind. Or. 3: *pl. 963.* 1845). According to Wight's text (op. cit. 3(3): 5), the specimens from which the drawing was made came from "the eastern slopes of the Neilgher-

ries by the roadside from Kottergherry to Matypolium . . ." The Wight specimen permits one to state with considerable assurance that he and Roxburgh had the same concept in mind for *Hippocratea obtusifolia.*

A fragmentary specimen of *Wallich 4216* (GH), which number is the source of the name *Hippocratea tortuosa,* is essentially identical with the other specimens mentioned above, and thus one is able to place this binomial of Wallich's with confidence.

The collections mentioned above, with two others, are the only specimens which at present I can confidently refer to *Loeseneriella obtusifolia.* Whether or not this species has a distribution outside of peninsular India needs reconsideration, in spite of the numerous floras and lists which have implied for it a very extensive range. Following are citations upon which my concept of the species is based:

INDIA: Bombay: Konkan ("Concan") District, *Stocks* (GH); Madras: Nilgiris, *Wight 465* (GH, NY); Aiyur, Salem District, *E. K. Kristman 41* (GH); cultivated: *Hort. Calcutta Botanic Garden,* without date, in flower (GH), Aug. 6, 1889, in fruit (GH) (specimens probably from type plant of *Hippocratea obtusifolia*); without data: *Wallich 4216* (GH) (source of the name *Hippocratea tortuosa*).

The advisability of separating the Old World species of this alliance from *Hippocratea* L. has recently been discussed by the writer (in Am. Jour. Bot. **28**: 439. 1941).

**Loeseneriella concinna** sp. nov. FIG. 1.

*Hippocratea obtusifolia* sensu Benth. Fl. Hongk. 62. 1861; Dunn & Tutcher in Kew Bull. Add. Ser. **10**: 62. 1912; non Roxb.

Frutex volubilis, ramulis gracilibus glabris primo fusco-purpureis demum saepe cinereis interdum copiose scabrido-lenticellatis; foliis oppositis glabris, petiolis inconspicuis supra canaliculatis 2–4 mm. longis, laminis chartaceis viridibus vel fusco-viridibus saepe nitentibus oblongo-ellipticis, (3–) 4–7 cm. longis, (1.2–) 1.5–3.5 cm. latis, basi obtusis vel subrotundatis et in petiolum decurrentibus, apice obtusis vel obtuse cuspidatis, margine crenato-serrulatis (dentibus 2 vel 3 per centimetrum saepe obscure calloso-apiculatis), costa utrinque valde elevata, nervis secundariis utrinsecus 4–6 patentibus brevibus anastomosantibus et rete venularum copioso intricato utrinque prominulis; inflorescentiis cymoso-paniculatis apicem ramulorum versus axillaribus 2–3.5 cm. longis et latis paucifloris, ramulis pedicellisque gracilibus leviter puberulis demum glabrescentibus, pedunculo communi 1–1.5 cm. longo, bracteis bracteolisque deltoideis acutis 0.6–1 mm. longis margine glanduloso-serrulatis; floribus glabris ultimis binis vel ternatis, pedicellis sub anthesi in dichotomiis 10–15 mm. longis alteris 5–10 mm. longis; sepalis papyraceis deltoideis subacutis, circiter 0.7 mm. longis, 1–1.5 mm. latis, margine basim versus obscure ciliolatis; petalis tenuiter carnosis oblongo-lanceolatis, 4–5 mm. longis, 1.7–2.5 mm. latis, apice calloso-mucronulatis, margine apicem versus obscure ciliolatis; disco carnoso annulari-pulvinato, basi 2–2.5 mm. diametro et obscure pentagono, 1–1.5 mm. alto, medium versus obscure constricto, apice angustiore et leviter crenulato; filamentis sub anthesi circiter 1.3 mm. longis et basi 0.6–0.8 mm. latis, superne angustatis, antheris 0.4–0.5 $\times$ 0.6–0.7 mm.; ovario in disco immerso trigono, ovulis in quoque loculo 4 oblique adscendentibus, stylo conico-subulato 0.8–1 mm. longo truncato; capsulis divergentibus obovato-

ellipticis, maturitate 3.5–6 cm. longis et 1.5–3.5 cm. latis, basi obtusis, apice emarginatis, pericarpio venis longitudinalibus anastomosantibus prominulis copiose striato; seminibus plerumque 4, ala basali submembranacea vel papyracea elliptica maturitate ad 3 × 2 cm. basi obtusa, parte embryonifera falcato-ellipsoidea ad 15 mm. longa.


FIG. 1. *Loeseneriella concinna; a.* flowering branchlet, × ½; *b.* detail of inflorescence, × ⅓; *c.* flower slightly before full anthesis, × 3; *d.* flower with two petals removed, × 3; *e.* fruit with one capsule aborted, × ½; *f.* seed, × ½. *Figs. a-d* drawn from the type, *e* from *Tsang 21743, f* from *Tsang 16674.*

CHINA: Hongkong: *Ford* (A); Lantao Island, Shantao, Tungchung and vicinity, *Y. W. Taam 2105* (A, TYPE), June 4, 1941 (fairly common on sandy stony slope among scattered shrubs; flowers yellow); Lantao Island, Taai Ue Shan, *Lingnan Univ. 16674* (*Tsang*) (A, NY) (in a ravine; fruit yellow; native name: *Ch'ing Heung Tsai Shue*); Kwangtung: Tung Koo Shan, Tapu District, *W. T. Tsang 21743* (A, NY) (fairly common on dry steep slope, in silty sandy rocky soil, among scattered shrubs [fruit]); Kwangsi: Shap Man Taai Shan, near Iu Shan village, Shang-sze District, Kwangtung border, *W. T. Tsang 22444* (A) (fairly common in thickets in silty clayey rocky soil; flowers yellow).

This species of southern China, which has been passing in herbaria as *Hippocratea obtusifolia* Roxb., may be readily distinguished from that Indian species, discussed above, as follows:

Petioles 4–10 mm. long; leaf-blades elliptic, often broadly so, 4–11 × 2.5–7 cm.; inflorescence ample, often as long as the leaves, many-flowered; pedicels 1.5–3 mm. long at anthesis, with the sepals brown-puberulent; style 1.2–1.6 mm. long; ovules 6 per locule. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *L. obtusifolia.*

Petioles 2–4 mm. long; leaf-blades oblong-elliptic, usually 4–7 × 1.5–3.5 cm.; inflorescence compact, shorter than the leaves, few-flowered; pedicels 5–15 mm. long at anthesis, with the sepals essentially glabrous; style 0.8–1 mm. long; ovules 4 per locule. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *L. concinna.*

**Loeseneriella Merrilliana** sp. nov. FIG. 2.

*Hippocratea obtusifolia* sensu Merr. in Lingnan Sci. Jour. 6: 328. 1928 [1930]; non Roxb.

Frutex volubilis, ramulis divaricatis glabris fusco-cinereis saepe copiose scabrido-lenticellatis; foliis oppositis glabris, petiolis robustis canaliculatis 5–8 mm. longis, laminis chartaceo-coriaceis in sicco fusco-viridibus subnitentibus oblongo-ellipticis, (5–) 6–10.5 cm. longis, (2–) 2.5–5.5 cm. latis, basi obtusis vel anguste rotundatis et in petiolum decurrentibus, apice


FIG. 2. *Loeseneriella Merrilliana; a.* flowering branchlet, × ½; *b.* flower with two petals removed, × 3; *c.* flower, × 3; *d.* fruit with one persistent capsule, × ½; *e.* seed, × ½. *Figs. a-c* drawn from the type, *d* and *e* from *How 73743.*

in acuminem obtusum 5–10 mm. longum abrupte cuspidatis, margine inconspicue crenato-serrulatis (dentibus circiter 2 per centimetrum obscure nigro-callosis), costa utrinque subprominente, nervis secundariis utrinsecus 4–6 adscendentibus utrinque paullo elevatis, rete venularum intricato utrinque priminulo vel supra subimmerso; inflorescentiis cymoso-paniculatis apicem ramulorum versus axillaribus 2.5–6 cm. longis saepe multifloris, ramulis pedicellisque dense sed minute farinoso-puberulis, pedunculo communi plerumque 1–1.5 cm. longo, bracteis bracteolisque deltoideis acutis 1–1.5 mm. longis subintegris; floribus ultimis binis vel ternatis, pedicellis gracilibus sub anthesi in dichotomiis 3–8 mm. longis alteris circiter 2 mm.

longis; sepalis ovato-deltoideis, 1–1.2 mm. longis, 1.5–1.8 mm. latis, apice obtusis, margine ciliolatis; petalis tenuiter carnosis oblongo-lanceolatis, 4–5 mm. longis, 1.7–2.5 mm. latis, apice dorso mucronulato-calcaratis, utrinque obscure farinoso-puberulis; disco carnoso annulari-pulvinato, basi 2–3 mm. diametro et obscure pentagono, 1–1.5 mm. alto, glabro, medium versus obscure constricto; filamentis ligulato-deltoideis 1–1.7 mm. longis, basi 0.8–1.5 mm. latis, superne angustatis, antheris 0.4–0.5 × 0.6–0.8 mm.; ovario in disco semi-immerso trigono, ovulis in quoque loculo 8, stylo conico-subulato 1–1.5 mm. longo truncato; capsulis immaturis obovato-ellipticis vel anguste ellipticis, ad 6 cm. longis et 3.2 cm. latis, basi obtusis et minute stipitatis, apice rotundatis vel emarginatis, pericarpio venis inconspicue striato, seminibus abortu paucis, ala basali membranacea late elliptica.

China: Hainan: Sin Woh, Taam Chau District, *W. T. Tsang 381* [Lingnan Univ. *17130*] (A, type; NY), May 19, 1928 (growing on the plain of a stream; flowers white, fragrant); Po-ting, alt. 350–550 m., *F. C. How 72209* (A), *73743* (A) (twining plants in forested ravines; flowers [*72209*] pale green; fruits [*73743*] lustrous green); Yeung Lam Shan, near Yeung Lam village, Yai Hsien, *S. K. Lau 6337* (A) (rare woody climber on dry steep slope on sandy soil in forest; flowers white); Yaichow, *H. Y. Liang 62274* (NY) (scandent, in forested ravine; immature fruits green).

This new species from Hainan differs from the plant of Hongkong, Kwangtung, and Kwangsi above described as *L. concinna* in several obvious characters, namely the longer petioles, the more coriaceous and larger leaf-blades with a more obvious acumen, the usually more ample inflorescence with shorter pedicels and larger sepals, the farinose-puberulent character of its inflorescence-branches and petals, and in having 8 rather than 4 ovules per locule. From the Indian *L. obtusifolia* (Roxb.) A. C. Sm. the new species differs in the proportionately narrower leaf-blades, which are more coriaceous in texture and have a more obvious acumen, in the longer pedicels and slightly larger petals, and in having 8 rather than 6 ovules per locule.

A closer relative of the new species is apparently the Indo-Chinese **Loeseneriella dinhensis** (Pierre) comb. nov. (*Hippocratea dinhensis* Pierre, Fl. For. Cochinch. 4: *pl. 301A*. 1893). The Hainan plant differs from this, however, in its fewer secondary nerves, its more ample inflorescence, and its less highly elevated disk. It should be noted that the Indo-Chinese specimen *Pételot 2119* (or *2219*) cited by Merrill (in Jour. Arnold Arb. 21: 374. 1940) as *Hippocratea obtusifolia* Roxb. is very close to the new species and possibly identical with it. However, *Pételot 2119* has the leaf-blades proportionately a little broader than our species, the pedicels shorter, and the ovules only 6 per locule. The Pételot plant is somewhat more suggestive of the true *L. obtusifolia* than the other specimens here discussed, but I doubt if it can be referred to the Indian species.

*Hippocratea obtusifolia* and *H. dinhensis* are placed by Loesener (in Nat. Pfl. ed. 2. 20b: 213. 1942) in *Hippocratea* subgen. *Euhippocratea* sect. *Barbatae*, the type-including section of *Hippocratea*, which in the writer's opinion (see Brittonia 3: 356–367. 1940) is a monotypic American genus.

**Loeseneriella yunnanensis** (Hu) comb. nov.

*Hippocratea yunnanensis* Hu in Bull. Fan Mem. Inst. Biol. **10**: 152. 1940.

CHINA: Yünnan: Pu-Erh Hsien, Po-Pien-Kiang, alt. 1100 m., *C. W. Wang 81219* (A, TYPE COLL.) (on open dry slope along river-bank; flowers greenish); Chu-yüan, *A. Henry 10865* (A,NY) (large climber; flowers green); Shih-Ling, alt. 1200 m., *A. Henry 13274* (A,NY) (climbing shrub).

This is another species of the general alliance of *L. obtusifolia* (Roxb.) A. C. Sm., to which it is very similar in foliage, differing perhaps in having slightly shorter petioles and thicker leaf-blades. The flowers of *L. yunnanensis* are noticeably larger (sepals about 1.5 × 2 mm.; petals 5–8 × 2.5–4 mm.) than those of *L. obtusifolia* (sepals 0.7–0.8 × 0.6–1.2 mm.; petals 3.5–4.5 × 1.5–2 mm.). The disk is less highly elevated, being only 1–1.5 mm. high but widening to a base 3.5–4 mm. across; the disk of the Indian species is 1.7–2.3 mm. in diameter but proportionately higher. The filaments of the Yünnan plant are longer (2–2.5 mm. rather than 1–1.5 mm.), and the ovules are 8–10 per locule rather than 6. The available fruits of the two species show no consequential differences. Hu compared his new species with *Hippocratea puberula* Craib, but that species has much larger and longer-petioled leaves and smaller flowers.

**Loeseneriella Arnottiana** (Wight) comb. nov.

*Hippocratea Arnottiana* Wight, Ill. Ind. Bot. **1**: 133. *pl. 46, 47A*. [1839]; Lawson in Hook. f. Fl. Brit. Ind. **1**: 624. 1875.

INDIA: Madras: *Wight 463* (GH, NY), *2445* (NY) (probably parts of TYPE COLL.); Kodaikanal Region, Palni Hills, Madura District, *Anglade* (A).

The Wight specimens cited above agree well with the original description and illustrations and are very probably a part of the type collection, cited without number; nos. *463* and *2445* are so similar that it seems likely that they are parts of a single original collection, subsequently re-numbered. The original locality is mentioned as "Malabar" by Wight, and as Quilon [Travancore State, Madras] by Lawson. The Anglade collection, from the same part of India, agrees precisely with *Wight 463* and *2445*. The species is very distinct in its large flowers (about 8 mm. in diameter at anthesis), spreading spatulate clawed petals, and papillose disk; the ovules are 8 or 10 per locule.

Loesener (in Nat. Pfl. ed. 2. **20b**: 214. 1942) places *Hippocratea Arnottiana* in *Hippocratea* subgen. *Euhippocratea* sect. *Scutellatae,* a synonym of *Prionostemma* Miers, a very different American genus in the writer's understanding (see Brittonia **3**: 391–396. 1940).

**Loeseneriella serrata** (Griffith) comb. nov.

*Hippocratea serrata* Griffith, Not. Pl. As. **4**: 473. 1854, Ic. Pl. As. **4**: *pl. 582*. 1854.

Griffith's species is difficult to interpret, due to the inadequacy of the original description and plate, but the latter is sufficiently clear to suggest with reasonable certainty that a species of *Loeseneriella* is represented, characterized by narrowly oblong-elliptic serrate leaf-blades and fairly short inflorescences. The original locality is given as: "Journey from Assam to Ava. Tsakan Delvi," probably in central Burma.

A specimen which agrees well with Griffith's plate is *Helfer 905* (GH), from "Tenasserim and Andamans." The leaves of this specimen are essen-

tially identical with those of the plate and agree with the description as to "costa venisque lutescentibus, subtus pallidioribus, . . ." The flowers of the Helfer specimen have the pedicels and sepals glandular-puberulent, the petals lanceolate-oblong, 3.5–4 mm. long, the disk obvious, the filaments and style about 1 mm. long, and the ovules 6 or 8 per locule.

## Pristimera Miers

**Pristimera indica** (Willd.) A. C. Sm. in Am. Jour. Bot. 28: 440. 1941.
*Hippocratea indica* Willd. Sp. Pl. 1: 193. 1797.

CHINA: Hainan: Ka Chik Shan and vicinity, Ch'ang-kiang District, *S. K. Lau 1675* (NY); Ue Lung Shan, Ch'ang-kiang District, *S. K. Lau 3131* (A); Pak Shik Ling and vicinity, Ching Mai District, *C. I. Lei 847* (NY); Yaichow, *H. Y. Liang 62979* (A, NY).

The above specimens are listed because the species appears not to have been otherwise recorded from China. Although, as indicated by herbarium records, *Pristimera indica* is a very widespread species, it is fairly variable as currently interpreted and its range cannot be stated without detailed study of the genus. The Hainan material, however, appears quite identical with that from India and Ceylon. Willdenow gives the original locality as "in India orientali."

**Pristimera setulosa** sp. nov. FIG. 3.

Frutex scandens, ramulis hornotinis acute quadrangularibus copiose setulosis (pilis 0.1–0.15 mm. longis, glandulosis [?]), annotinis glabrescentibus, vetustioribus teretibus cinereis; foliis oppositis glabris, petiolis gracilibus leviter canaliculatis 3–5 mm. longis, laminis chartaceis in sicco fusco-viridibus ellipticis, 4–6.5 cm. longis, 2–3.5 cm. latis, basi obtusis vel subacutis et in petiolum decurrentibus, apice obtusis vel breviter et obtuse cuspidatis, margine crenulato-serrulatis (dentibus 5 vel 6 per centimetrum inconspicuis), costa utrinque valde elevata, nervis secundariis utrinsecus 4 vel 5 arcuato-adscendentibus supra subplanis subtus prominulis, rete venularum supra immerso subtus laxe prominulo; inflorescentiis solitariis vel binis in axillis foliorum saepe delapsorum subdichotome cymosis multifloris 1.5–3 cm. longis et latis, pedunculo ad 17 mm. longo ramulisque quadrangularibus et copiose setulosis, bracteis papyraceis glabris deltoideo-oblongis 0.5–0.8 mm. longis acutis, bracteolis similibus minoribus; floribus in ramulis ultimis binis pedicello gracili 0.6–0.8 mm. longo obscure setuloso excepto glabris; sepalis papyraceis deltoideo-oblongis, 0.4–0.5 mm. longis, circiter 0.3 mm. latis, obtusis, margine erosulis; petalis tenuiter carnosis elliptico-oblongis, circiter 1 mm. longis et 0.5 mm. latis, apice obtusis, integris, utrinque obscure papillosis, glabris; disco obscuro minutissime annulari; staminibus 3 minutis, filamentis ligulatis circiter 0.15 mm. longis, antheris circiter 0.1 × 0.15 mm.; ovario depresso-subgloboso sub anthesi circiter 0.4 mm. diametro 3-lobato, ovulis in quoque loculo 2 collateralibus, stylo inconspicuo circiter 0.15 mm. longo truncato.

CHINA: Yünnan: Man-hao [on Yang Chiang (Red River) near Indo-Chinese boundary], *A. Henry 9612* (NY, TYPE) (large climber with yellow flowers, coll. June 19 [year?]).

The new species differs from the common *P. indica* (Willd.) A. C. Sm., which apparently does not occur in interior China, in its densely setulose

young branchlets and inflorescence-branches. The hairs are very abundant, stand out stiffly, and are glossy when expanded, as though glandular in nature. The young branchlets and inflorescence-branches are sharply quadrangular, whereas these parts in *P. indica* are usually subterete.


FIG. 3. *Pristimera setulosa; a.* flowering branchlet, × ½; *b.* detail of inflorescence, × 3; *c.* young flowers, × 5; *d.* flower with two petals removed, × 20. Drawn from the type.

**Pristimera arborea** (Roxb.) comb. nov.

*Hippocratea arborea* Roxb. Hort. Beng. 5, nomen. 1814, Pl. Coast Corom. 3: 3. *pl. 205.* 1819, Fl. Ind. 1: 171. 1820.

INDIA: Cult. Calcutta Botanic Garden, *Wallich 4212C* (NY), *Collector?,* Feb. 22, 1901 (A); "East Himalaya," *Griffith 910* (GH); "W. Himalaya," *J. F. Duthie* (A). BURMA: (Without data), *J. C. Prazer 23* (NY). CHINA: Yünnan: Puerh cliffs, alt. 1800 m., *A. Henry 13203* (A) (large climber); Sheau-meng-yeang, Che-li Hsien, alt. 960–1000 m., *C. W. Wang 75610* (A), *79608* (A) (vines, in woods on mountain-slopes; capsules green).

The Wallich specimen cited above is listed under *Hippocratea arborea* Roxb. by Wallich (Cat. no. 4212C. [1830]) as "HBC.," thus indicating that it was taken from a plant cultivated in the Calcutta Botanic Garden. In habit this Wallich specimen agrees precisely with Roxburgh's descriptions and illustration; in floral details these descriptions and the illustration are highly inaccurate, which is not surprising in view of the fact that at anthesis the flower is little more than 1 mm. in diameter. However, there

seems no doubt that Roxburgh had at hand a species of *Pristimera* closely allied to *P. indica* (Willd.) A. C. Sm. The original collection is said to have come from the "interior parts of India," and Roxburgh (Pl. Coast Corom. 3: 4. 1819) states that the species was in cultivation at Calcutta. It seems very likely, therefore, that the Wallich specimen was taken from the type plant or a descendant of it.

It is also possible that the fruiting specimen cited above (*Collector?*, Feb. 22, 1901) came from a descendant of Roxburgh's original plant, although its leaves are slightly thicker and less obviously serrate than those of *Wallich 4212C*. In its fruit, the collection of 1901 seems to agree well with Roxburgh's concept.

Of the other Indian specimens cited above, *Griffith 910* has inflorescences identical with those of *Wallich 4212C*, although its leaves are somewhat more coarsely serrate; I believe that the Griffith specimen can be referred here with reasonable certainty. It is probably part of the same collection which was questionably referred to *Hippocratea arborea* by Lawson (in Hook. f. Fl. Brit. Ind. 1: 625. 1875), as from "Bhotan and the Khasia Mts." The Duthie specimen consists of young leaves and inflorescences and is accompanied by mature fruits; it is referred to the species with confidence. Lawson (l. c.) states that this species differs from *Hippocratea indica* "apparently in nothing but size." The two species are indeed very similar in inflorescence characters, but the much larger leaves and fruits of *Pristimera arborea* make it readily recognizable.

The cited Burmese specimen is remarkably similar to *Wallich 4212C* in both foliage and inflorescences, while the cited Chinese specimens, all in fruit, seem undoubtedly to belong here. The range of the species is thus from northeastern India across [northern?] Burma to southern Yünnan. Apparently it has not previously been recorded outside of India.

**Pristimera cambodiana** (Pierre) comb. nov.

*Hippocratea cambodiana* Pierre, Fl. For. Cochinch. 4: *pl. 302B*. 1893; Pitard in Lecomte, Fl. Gén. Indo-Chine 1: 896. 1912.

INDO-CHINA: Cambodge: Samrong-tông, *L. Pierre 869* (COTYPE COLL., A, NY). CHINA: Yünnan: Lan-Tsang Hsien, alt. 890–1100 m., *C. W. Wang 73135* (A), *76712* (A) (woody vines, on mountain slope or on outcrop on river-bank). Upper BURMA: *J. C. Prazer* in 1894 (A, 2 sheets), *39* (NY).

A single flower associated with *Wang 73135* agrees precisely with the flowers described and well figured by Pierre. The species is marked by its small flowers, involute petals, inconspicuous disk, and 6-ovulate locules. In foliage, the cited Chinese specimens agree very well with the available cotype collection. *Wang 76712* bears juvenile fruits, the capsules of which are much shorter than those of *Pierre 869* but similar in texture. The cited Prazer specimens from Burma agree precisely with *Pierre 869* in foliage, and the available capsules are identical in shape with those of the Pierre specimen but are shorter, perhaps due to immaturity.

These collections extend the range of the species to southern Yünnan and northern Burma; otherwise it has been recorded only from the southern part of Indo-China (Cochinchine and Cambodge).

*Pristimera cambodiana* differs from the widespread *P. indica* (Willd.) A. C. Sm. in its much larger leaves, flowers, and fruits, its 6- rather than 2-ovulate locules, and in other obvious characters. Nevertheless the floral characters of the two species are fundamentally similar, and I believe that Pierre's species is safely referable to *Pristimera,* as emended by the writer in Brittonia 3: 367–383. 1940, and in Am. Jour. Bot. **28**: 440. 1941.

A closer relative of *P. cambodiana* is **Pristimera Grahamii** (Wight) comb. nov. (*Hippocratea Grahamii* Wight, Ill. Ind. Bot. **1**: 134. [1839], Ic. Pl. Ind. Or. **2**: *pl. 380.* 1840). From this Indian species, *P. cambodiana* differs in its somewhat larger leaves, shorter pedicels, glabrous rather than faintly puberulent disk, and longer filaments and style. *Pristimera Grahamii* is represented by two specimens collected by Law (GH) in the Kanara District, Bombay; the type (coll. Graham) is said to have come from Bombay.

It should be noted that *Wang 73135* was cited by Hu as the type of *Mangifera austro-yunnanensis* (in Bull. Fan Mem. Inst. Biol. **10**: 160. 1940). This circumstance is doubtless due to a mixture of numbers, as the data on the field label of our specimen are different, while Hu's description of the *Mangifera* obviously does not pertain to our plant.

Both *Hippocratea cambodiana* and *H. Grahamii* are placed by Loesener (in Nat. Pfl. ed. 2. **20b**: 216. 1942) in *Hippocratea* subgen. *Euhippocratea* sect. *Thyrsiflorae,* whereas *Hippocratea indica* and *H. arborea* are placed by him in *Hippocratea* subgen. *Euhippocratea* sect. *Micranthae* (op. cit. 212).

## SUMMARY

Three new Chinese species of Hippocrateaceae are above described and seven new combinations are proposed in *Loeseneriella* and *Pristimera* for species of southeastern Asia. The seven species of capsular-fruited Hippocrateaceae now known from China may be keyed as follows:

Flowers comparatively large, the petals at least 4 mm. long, often spreading at anthesis, the disk conspicuous, annular-pulvinate, 1–1.5 mm. high, slightly constricted near the middle; capsules usually obovate-elliptic (*Loeseneriella*).

Inflorescence-branches and pedicels essentially glabrous, the pedicels 5–15 mm. long at anthesis; ovules 4 per locule; petioles 2–4 mm. long; leaf-blades usually 4–7 × 1.5–3.5 cm. (Hongkong, Kwangtung, Kwangsi)..*Loeseneriella concinna.*

Inflorescence-branches and pedicels puberulent at anthesis, the pedicels 2–8 mm. long at anthesis; ovules 8–10 per locule; leaf-blades 5–10.5 × 2–6 cm.

Leaf-blades oblong-elliptic, the acumen 5–10 mm. long; petioles 5–8 mm. long; petals 4–5 × 1.7–2.5 mm.; filaments 1–1.7 mm. long (Hainan)............ ..........................................*Loeseneriella Merrilliana.*

Leaf-blades elliptic, obtuse or short-cuspidate; petioles 2–5 mm. long; petals larger, 5–8 × 2.5–4 mm.; filaments 2–2.5 mm. long (southern Yünnan)..... ..........................................*Loeseneriella yunnanensis.*

Flowers small, the petals less than 3 mm. long, suberect at anthesis, the disk obscure, scarcely apparent as a pulvinate thickening at base of stamens; capsules narrowly oblong (*Pristimera*).

Petals about 1 mm. long at anthesis; ovules 2 per locule; capsules 2-seeded.

Leaf-blades chartaceous, usually 3.5–10 × 2–5 cm.; capsules at maturity (not known for *P. setulosa*) 3–4.5 × 1–1.5 cm.

Young branchlets and inflorescence-branches glabrous, usually subterete (Hainan; also India, Indo-China, Malaysia, etc.)...... *Pristimera indica.*

Young branchlets and inflorescence-branches densely setulose with apparently glandular hairs, sharply quadrangular (Yünnan)..... *Pristimera setulosa.*

Leaf-blades chartaceous to subcoriaceous, usually 10–17 × 5–9 cm.; capsules at maturity 6.5–9.5 × 2.5–3.5 cm. (southern Yünnan; also northeastern India and Burma)........................................ *Pristimera arborea.*

Petals 2.5–3 mm. long at anthesis; ovules 6 per locule; capsules 7–10.5 × 2–3 cm., usually 6-seeded; leaf-blades coriaceous, usually 12–15 × 5–9 cm. (southern Yünnan; also Indo-China and Burma)............... *Pristimera cambodiana.*

In addition to these seven species, another apparently undescribed species of *Loeseneriella* from China is represented by *R. C. Ching 6573* (NY), from Chang Tung, E. Tan Shan, Kwangsi. This is a distinct species with copiously pubescent petals, but the collection seems inadequate to be the sole basis of a new species.

ARNOLD ARBORETUM,
HARVARD UNIVERSITY.

# A NEW SPECIES OF ISOETES FROM NEW GUINEA*

A. H. G. ALSTON

**Isoëtes habbemensis** sp. nov.

Rhizoma bilobatum(?), circa 3.5 × 1.5 cm., 1 cm. altum, appresse semiglobosum, sursum foliorum fasciculum gerens, subtus radicibus nigrobrunneis circa 2 mm. in diametro dense indutum. Folia leviter curvata, usque ad 14 cm. longa, medio circa 3 cm. in diametro, in sectione semicircularia, dorso rotundata, supra subplanata, nervo subprominente et marginibus leviter alatis; foliorum parte superiore viride, lacunis circa 4 mm. longis, apicibus fallentibus; parte inferiore foliorum circa 3 cm. longa, pallide rufo-fuscescente, basin versus late alata usque ad 1 cm. lata. Stomata nulla. Ligula deltoidea. Velum nullum. Sporangia obovato-oblonga, circa 1 cm. longa, 4 mm. lata, multilocularia. Megasporae circa 575 μ in diametro, sublaeves, valde tricarinatae, siccitate pallide griseo-albidae. Microsporae dense echinulatae, circa 43 μ in diametro, siccitate fuscescentes.

NETHERLANDS NEW GUINEA: Lake Habbema, alt. 3225 m., *Brass 9440* (TYPE in herb. Brit. Mus.), *9441* (form with short recurved leaves), very abundant in marginal shallows; 4 km. N. E. of Wilhelmina-top, alt. 3660 m., *Brass & Myer-Drees 9974* (form with shorter leaves), common in stony shallows of a lake. The cited specimens are deposited in the herbarium of the British Museum, and duplicates are in the Gray Herbarium.

This species is separated from *I. neoguineensis* Bak., the only other species recorded from New Guinea, by its nearly smooth megaspores, which are very slightly rugose on the back. These megaspores are greyish white when dry and light brown when wet. *Isoëtes neoguineensis* was first collected by A. Giulianetti on Mount Scratchley at 10000–13000 ft., and recently by Brass (no. *4366*) in the shallows of an alpine lake at 3680 m. on Mount Albert Edward. The megaspores were incorrectly described as "laeves" by Baker; they are strongly tuberculate. *Isoëtes philippinensis* Merrill & Perry, from a stream at 400–500 m. near Momungan, in Lanao Province of Mindanao, is separated by the reticulate sculpturing of its megaspores. The megaspores of I. *sinensis* Palmer, which was found in a pond near the Ming tomb in Spirit Valley (Nanking), are conspicuously crested. The other Chinese species, *I. hypsophila* Hand.-Maz., from moorland pools at 3600 m. in Yunnan, has smooth mega- and microspores, while the Indian *I. coromandeliana* L. f. has tuberculate megaspores.

BRITISH MUSEUM (NATURAL HISTORY),
LONDON.

*Botanical Results of the Richard Archbold Expeditions.

# NEW OR CRITICAL EUPHORBIACEAE FROM THE AMERICAS

L. Croizat

*With one plate*

This paper consists of the descriptions of various new species and varieties, a new genus *Moacroton* from Cuba, and critical notes and records, reductions, and transfers. Unless otherwise stated, the types of the forms herein described are preserved in the herbarium of the Arnold Arboretum.

## Phyllanthus Linnaeus

**Phyllanthus vichadensis** sp. nov.

Fruticulus caules strictos plures erectos e rhizomate perenni edens, ramis glaberrimis exalatis subexalatisve. Foliis ellipticis carnosulis enerviis 5–7 mm. longis, 2 mm. latis, utrinque aequo iure acuminatis petiolulo ca. 1 mm. longo, stipulis subsetaceis integris ca. 2 mm. longis. Floribus secus apicem ramulorum dispositis, ♂ ad 3 capitulatim aggregatis subsessilibus, ♀ longius pedicellatis saepissime singulis. Perianthio ♂ ca. 2 mm. longo 2.5 mm. lato 5-lobo, antheris 3 in columna ca. 1.5 mm. alta coalitis longitudinaliter dehiscentibus, columna basi incrassata revera haud glandulosa. Perianthio ♀ magnitudine fere ♂ 5-lobo, lobis costatis rotundato-ellipticis, disco nullo subnullove, ovario globuloso depresso ca. 1 mm. in anthesi magno, stylis 3 ca. 1 mm. longis e basi liberis subliberisve apice bilobato partitis, pedicello sub fructu nonnihil apice incrassato ad 4 mm. longo.

Colombia: Comisaria El Vichada: About 70 km. southeast of Orocué, *Haught 2779.*

This new species is described as an inconspicuous perennial of the open *llanos*. Its habit is reminiscent of *P. diffusus* Kl., an annual weed with which it was originally confused in the herbarium. Fragments of *Leprieur 319* and *Schomburgk 529* in our herbarium show that it definitely differs from *P. hyssopifolioides* H. B. K. (well represented by *Williams 15945a;* Venezuela, Amazonas, Puerto Ayacucho) and *P. guianensis* Kl. in foliage as well as in floral characters. It may be remarked that the habit and gross morphology of the latter is reminiscent of the species in the vicinity of *P. caroliniensis* Walt.

## Croton Linnaeus

**Croton caboensis** sp. nov.

Frutex lignosus innovationibus pallide ochraceis velutino-hispidis demum glabratis. Foliis pro more ovatis, interdum lanceolatis vel oblongo-ovatis, 5–8 cm. longis, 2–5 cm. latis, olivaceo-brunneis vel brunneis, submembranaceis, subtus laxius stellato-pubescentibus subgriseis, supra pilis subsimplicibus more proprio adpressis setoso-pubescentibus, apice breviter acuminatis, basi rotundatis vel leviter cuneatis, margine subintegris ciliatis, nervis adscendentibus ca. 7–9-jugis, primo jugo ramoso, glandulis stipulisque

nullis subnullisve, petiolo tomentello gracili, 0.5–2.5 cm. longo. Inflorescentia spicata brevi ad 4 cm. longa. Floribus ♂ gracilius pedicellatis, pedicello ca. 3 mm. longo, perianthio totidem lato longoque, petalis sepalisque subaequalibus, staminibus ad 15. Floribus ♀ : perianthio ca. 3 mm. longo, totidemque lato, apetalo, lobis 5 fere ad basem liberis, costulatis, caeterum glabratis tenuibusque margine integris, ovario subglobuloso pallide ochraceo hispido ad 3 mm. magno, stylis 3, cruribus fere ad basem partitis, 3.2 mm. totis longis, glandulis 5 discretis, pedicello crasso ca. 1 mm. longo, semine ca. 7 mm. longo, 3–3.5 mm. lato, pallido, valde nitido, testa facie anteriori praesertim obscurissime grosseque rugulosa, caruncula subquadrangula parva, columella fructu delapso ad 7 mm. longa, coccis tomento hispido indutis, epicarpio verruculoso.

MEXICO: Baja California: Todos Santos, Cape Region, *T. S. Brandegee s. n.*, Oct. 4, 1899 (TYPE, Herb. Univ. Calif.); San José del Cabo, *T. S. Brandegee s. n.*, Sept. 11, 1891; Corral Piedras, *Katharine Brandegee s. n.*, Sept. 16, 1893.

My first impulse on examining this peculiar plant was to treat it as a subspecies of *C. fragilis* H. B. K., for it clearly belongs in the affinity of that species. However, a careful study of the group of *C. fragilis* H. B. K. as a whole indicated that if this form be placed under that species it was necessary to merge under this binomial numerous other allied forms that have uncontroversially been named, characterized and accepted as distinct entities. In addition, the apparently substrigose indumentum of the upper surface of the leaf, the large and shiny seeds, and the very hispid indumentum of the young capsules are characters which separate *C. caboensis* Croiz. from all other allies of *C. fragilis* H. B. K. at a glance. Baja California, lastly, is well known as a region of much endemism. *Croton flavescens* Greenm. has a quite different indumentum, and sharp keels on its capsule valves.

**Croton culiacanensis** sp. nov.

Frutex 1–2 m. altus, innovationibus tenuiter puberulis griseis, citius glabratis. Foliis lanceolato-ovatis vel lanceolatis, 3–7 cm. longis, 1.5–4 cm. latis, subtus griseo-tomentulosis, supra pallide viridibus, apice breviter acuminatis, basi rotundatis vel cuneato-rotundatis, eglandulosis sed laminae ipsius basi more proprio subauriculato-callosa, margine subintegris, venis ca. 5–6-jugis primo jugo laminam dimidiam attingente, petiolo graciliore 1–2.5 cm. longo, stipulis subnullis. Inflorescentia 2-sexuali, spicata, gracili, ad 10 cm. longa. Floribus ♂ : perianthio delicato ca. 2 mm. longo, 3 mm. lato, petalis sepalisque subaequilongis, staminibus ca. 15–20. Floribus ♀ : perianthio vix 2 mm. magno albicante, lobis (fructu ineunte) ca. 3.5 mm. longis 2 mm. latis, margine subreduplicativis subintegris, costatis, petalis nullis, glandulis in disculum connatis latis at haud conspicuis, ovario ca. 2 mm. longo latoque albicante, hispidulo, obvie 3-cocco, stylis 3, quove iteratim partito, ca. 2.5 mm. longo.

MEXICO: Sinaloa: Culiacán, *E. Palmer 1507* (TYPE); Ymala, *E. Palmer 1446;* Culiacán, *Brandegee s. n.*, 1904; Mazatlán, *Eyerdam & Beetle 8660.*

Currently this has been identified as representing *C. Watsonii* Standl., or as *C. Ortegae* Standl. It is close to both in its affinities, but cannot easily be confused with either. *Croton Watsonii* Standl. is endemic to the eastern coast of Mexico, and has much larger ♀ flowers, with a definitely

silvery indumentum; the undersurface of the leaf is silvery lepidote, not puberulous or tomentose. *Croton Ortegae* Standl. which is known from the western coast of Mexico, also has much larger ♀ perianths, styles cleft but once, smaller ovaries, and, above all, conspicuous tubular glands at the apex of the petiole. In *C. culiacanensis* Croiz. no glands appear, and the base of the blade is somewhat corrugated, and subauriculate in a peculiar manner.

**Croton gynopetalus** sp. nov.

Frutex, innovationibus griseo-tomentosis tardius glabratis. Foliis ovatis, 2.5–5 cm. longis, 0.5–2.5 cm. latis, utrinque sed subtus magis conferte tomentosis, supra olivaceis subtus cinereis vel cinereo-roseatis apice latius acuminatis basi rotundato-cuneatis vel rotundatis, margine subintegris vel plus minusve grosse dentato-serratis, penninerviis, nervis ca. 5–8-jugis adscendentibus, glandulis subsessilibus patelliformibus ceraceis obviis 2, petiolo 1–1.5 cm. longo, stipulis fere nullis. Inflorescentia spicata ca. 3–5 cm. longa. Floribus ♂: perianthio in alabastro ca. 2 mm. magno, staminibus, ut videtur, 10–12, pedicello brevissimo. Floribus ♀: perianthio ca. 3 mm. longo, 2 mm. lato, lobis 5 erectis, postico 1 minore, caeteris subaequalibus obovato-ligulatis, integerrimis, petalis setaceis, ovario ellipsoideo ca. 2 mm. longo tomentello griseo, stylis 3 ad basem partitis ca. 2 mm. longis, disco sat evoluto.

MEXICO: Oaxaca: San Geronimo, *Purpus 7159* (TYPE, Herb. Chicago Nat. Hist. Museum).

The position of this new species is doubtful. The material now available clearly shows that a complex of more or less closely related forms ranges between Guatemala and Vera Cruz, speciating as follows: (1) by more or less extensive reductions in the size of the lobes of the ♀ perianth which are nearest the axis of the inflorescence, and by an increase in the number of the lobes so reduced; (2) by a tendency in the foliage to become stabilized either as entire or as serrate, the difference between extremes being of specific order, all floral characters left aside; (3) by variations in the size of the ♀ perianth and capsule.

To the complex just mentioned belong: (a) *C. jutiapensis* Croiz., Guatemala; (b) *C. itzaeus* Lund., Yucatán; (c) *C. gynopetalus* Croiz., Oaxaca; (d) *C. ramillatus* Croiz. and its var. *insignilobus* Croiz., Chiapas and Vera Cruz. Of these five entities, two, *C. ramillatus* Croiz. and *C. jutiapensis* Croiz. have plainly anisomerous ♀ perianths, the remaining three showing also some irregularity in the size of the lobes of the ♀ flower, one or more of which tend to be smaller than the rest. This group, consequently, varies in the ♀ perianth in a manner strongly suggesting the modifications taking place in this organ in *C. capitatus* Michx., *C. Palmeri* S. Wats., *C. leucophyllus* Muell.-Arg. of northeastern Mexico and Texas, and in *C. mentiens* (S. Moore) Pax and its allies of Brazil.

*Croton gynopetalus* Croiz. has foliage intermediate between that of *C. ramillatus* Croiz. and *C. itzaeus* Lund., that is, more or less entire to dentate-serrate. It differs from both in the presence of petals in the ♀ perianth; from the former also in the much larger perianth-lobes, only

one lobe being reduced; and from the latter in the much less pubescent and grayish, more definitely ellipsoid ovary. The position of *C. ramillatus* Croiz. var. *insignilobus* Croiz. is still doubtful as between *C. ramillatus* Croiz. and *C. gynopetalus* Croiz., and will remain so until the full significance of the petals in the ♀ flower of single known collection of the latter is ascertained.

**Croton ramillatus** sp. nov.

Fruticulus lignosus, videtur dioecius, plus minusve intricatim ramosus, innovationibus trichomatibus stellatis haud delicatis pallide luteis vel subcinereis vestitis, citius glabratis. Foliis ellipticis vel ovato-lanceolatis, utrinque fere aequo jure attenuatis tomentosisque, supra brunneis vel olivaceis subtus sordide cinereis, margine integerrimis, nervis adscendentibus ca. 5–7-jugis penninerviis, glandulis tubulosis minimis vel saepius subnullis, petiolo sat gracili 3–5 mm. longo. Inflorescentiis exacte spicatis, plerumque 7–10 cm. longis. Floribus ♂: staminibus ca. 10 in perianthio ca. 2 mm. longo latoque, pedicello vix 1.5–2 mm. longo. Floribus ♀: perianthio habitu erecto, more proprio anisolobo, scilicet lobis posticis ca. 4 valde diminutis subsetaceis ad 1 mm. longis, anticis ca. 3 ligulatis rotundatis margine integerrimis ca. 2 mm. longis, disco valde adpresso subnullove, ovario rotundato pallide hispidulo ca. 1.5 mm. longo latoque stylis 3, quove ad basem partito ca. 2 mm. longo, capsula sub fructu glabrata, coccis subtrigonis vel potius lineato-carinatis.

MEXICO: Vera Cruz: Barranca de Panoya, *Purpus 8450* (TYPE, Herb. Chicago Nat. Hist. Museum); Zacuapan, *Purpus 2114, 2415;* Mata Zarza, *Purpus 9324.* Three ♂ collections, all from Vera Cruz, *Purpus 14045, 14145, 16369,* may also belong here.

This new species has been confused with *C. rhamnifolius* H. B. K. and *C. sphaerocarpus* H. B. K. (*C. morifolius* Willd. sensu Muell.-Arg.), which it hardly resembles at all. In its vegetative characters it strongly suggests *C. Sutup* Lund., but the erect ♀ flower with uneven lobes up to 8 in number, and the simple cleft styles set it apart from that species in a decisive manner.

**Croton ramillatus** var. **insignilobus** var. nov.

A var. *typico* lobis perianthii ad 5, anticis majoribus, postici minus diminutis, capsula — ut videtur — paullo majore discedit.

MEXICO: Chiapas: East of Monserrate, *Purpus 10066* (Herb. Univ. Calif.).

This variety is discussed under *C. gynopetalus* Croizat.

**Croton Shreveanus** sp. nov.

Frutex ca. 2-metralis, innovationibus apice hispido-lanulosis citius glabratis. Foliis griseo-viridibus longe ovatis vel elliptico-ovatis, 5–12 cm. longis, 2.5–6.5 cm. latis, stipellis anticis 2–4 (neque glandulis more generis veris) ad costae originem positis, limbo apice sat breviter acuminato, basi rotundato vel subcordato, margine tenuissime glanduloso-serrato, primum tomenti copia griseo vel griseo-olivaceo, citius utrinque glabrato at margine setuloso, nervis adscendentibus ca. 6-jugis, petiolo ca. 1–2 cm. longo, stipulis subnullis, primo tomentoso dein glabrato sed hinc inde semper hispido. Inflorescentiis spicatis ad 13–15 cm. longis. Floribus ♂: perianthio ca. 3 mm. lato, 2.5–3 mm. longo, petalis sepalisque subaequilongis, staminibus ca. 15, filamentis basi valde lanulosis. Floribus ♀:

perianthio minuto, vix 1.5–2 mm. lato, 1–1.5 mm. longo, lobis valde acutis triangularibus integris vix accrescentibus, petalis minimis ligulatis, ovario globuloso ca. 1.5 mm. magno, albicante, hispidulo, stylis 3 ca. 5 mm. longis, cruribus ad tertium inferum partitis.

MEXICO: Sinaloa: Capadero, Sierra Tacuichamona, 3000 feet above sea-level, "slender spreading shrub 2 m. high," *Gentry 5580* (Herb. Univ. Calif.; duplicate in Herb. F. Shreve).

This shrubby species belongs in the affinity of *C. adspersus* Benth., which also occurs in western Mexico but ranges southward. It is a very distinct entity, easily recognized by the peculiar stipellae of the limb, reminiscent of the appendages of certain species of *Alchornea* Sw., but very seldom found in *Croton*. It is not *C. Roxanae* Croiz. from Nayarit, Sinaloa and, possibly, Guerrero, which is directly allied with *C. sphaerocarpus* H. B. K., and *C. fragilis* H. B. K.

**Croton sancti-lazari** sp. nov.

Fruticulus dioecius intricatus, innovationibus tomento stellato hispido pallide citrino vel aurantiaco parcius indutis, serius glabratis. Foliis ellipticis vel sublanceolato-ellipticis 1–2 cm. longis, 0.3–0.9 cm. latis, integerrimis, apice plus minusve late rotundatis, basi rotundato-cuneatis, subtus cinereis vel pallide luteis hispido-tomentosis, supra viridibus tomento stellato dissito glabratis, tenellis toto hispido aurantiacis vel fulvescentibus, haud lepidotis, nervis adscendentibus ca. 5–7-jugis, petiolo brevissimo 3 mm. longo vel minore, glandulis nullis, stipulis subcarnosis, triangularibus. Inflorescentiis spicato-capitatis aurantiacis vel lutescentibus, pro more oliganthis. Floribus ♂: perianthio hispido-tomentoso ca. 2 mm. lato, 1.5 mm. longo, lobis triangularibus, petalis glabris subaequilongis, staminibus ca. 10. Floribus ♀: perianthio vix 2 mm. longo latoque, lobis acutis triangularibus, petalis (videtur) nullis, ovario trigono subglobuloso dilute aurantiaco grossius tomentoso ca. 2 mm. longo, 1.5 mm. lato, stylis 3 carnosulis, ca. 2–2.5 mm. longis, quove fere ad basem partito, semine ovato apice sat acuminato ca. 3 mm. longo, 2 mm. lato.

MEXICO: Coahuila: South of Castaños, rocky slopes of El Puerto de San Lazaro, *Wynd & Mueller 155* (TYPE ♂, Herb. Arnold Arb.; ♀ Herb. F. Shreve); Coahuila-Chihuahua boundary: Sierra Almagre, "bushy 1–2 feet tall, on floor of open canyons," *Johnston & Mueller 1141* (Herb. Gray).

A very strong species, related, but not closely, to *C. hypoleucus* Schlecht. and its group. It suggests in certain of its vegetative parts dwarfed states of *C. fruticulosus* Torr. The absence of lepidote hairs throughout well separates *C. sancti-lazari* Croiz. from somewhat similar early spring growth forms of *C. neomexicanus* Muell.-Arg., as represented by *M. E. Jones 29177* collected near Laredo, Texas.

**Croton lotorius** sp. nov.

Frutex ca. 5-pedalis, ligneus perennis, innovationibus laxe cinereo-tomentellis. Foliis griseo-viridibus supra glabratis subtus tenuiter griseo-tomentosis, ovatis, 3–5-plinerviis, 2.5–5 cm. longis, 1.5–3 cm. latis, nervis ca. 6-jugis patentibus vix anastomosatis, margine obtuse dentatis vel duplicato-dentatis crenis glandulosis ad 4 per cm., apice plus minusve acuminatis, basi rotundatis, petiolo gracili 1–2 cm. longo apice glandulis 2 stipitatis ornato, basi stipulis acutis vel setaceis integris fulto. Infloreseen-

tiis gracilibus spicatis 2-sexualibus ca. 10 cm. longis. Floribus ♂ : perianthio ca. 1.5–2 mm. lato, staminibus paucis, pedicello ca. 1 mm. longo. Floribus ♀ : perianthio inter generis minimo vix 1.5–2 mm. longo subcampanulato, pedicello ca. 0.5 mm. longo; calyce hispidulo, fere ad basim partito, lobis integris apice virescentibus, ovario globuloso hispidulo albicante, stylis gracilibus ca. 2 mm. longis partitis. Caetera desunt.

GUATEMALA: Huehuetenango: Between Santa Ana Huista and Rancho Lucas, Sierra de los Cuchumatanes alt. 800–900 m., *Steyermark 51332*.

This plant is used in baths and is locally known as "sanalotodo," a name frequently given to herbs supposed to be panaceas. It suggests *C. trinitatis* Millsp., but that is a strictly herbaceous plant, while *C. lotorius* Croiz. is manifestly woody, and differs further in the characters of its indumentum.

**Croton pyriticus** sp. nov.

Arbor 20-metralis et ultra alta. Innovationibus lepidotis, lepidibus centro brunneis inde indumento velato. Foliis firme chartaceis late ovatis vel triangulari-ovatis 4–9 cm. latis, 4–11 cm. longis, apice abrupte breviterque acuminatis, basi truncatis vel coarctato-cuneatis, margine subintegris repandulisve, adultis supra dissite leproso-lepidotis, subtus copia lepidum brunneo-argenteis vel more proprio subaureis (inde nomen specificum, e pyritis nitore desumptum), nervis utrinque manifestis late adscendentibus ca. 6-jugis, primo jugo majore ramoso, glandulis nullis, petiolo 1.5–6 cm. longo, stipulis nullis. Inflorescentiis apicalibus lateralibusque spicatis ad 10 cm. longis, interdum 1-sexualibus paniculato-ramosis. Floribus ♂ ca. 4 mm. longis, 7 mm. latis, lobis late ovatis petalis subaequilongis, staminibus ca. 15. Floribus ♀ ca. 7 mm. longis, fere totidem latis, perianthio ad basem partito, lobis late ovatis abrupte acuminatis ca. 2.5 mm. latis margine indumento molli sulphureo tectis dorso leproso-lepidotis, petalis obovato-ligulatis ad 2 mm. longis, aeque ac lobis margine indutis, ovario globuloso ca. 2 mm. magno, subargenteo-lepidoto, evoluto sub lente gravi nonnihil verrucoso, stylis pluri-partitis carnosulis ad 4 mm. longis, semine (e *Davidson 865,* in capsula ad specimen tantum solutum) 15 mm. longo, 10 mm. lato, antice ad latera compresso lineolis 3–4 e caruncula ortis obliquis utrinque exarato, rubro-brunneo maculoso-striato, postice nonnihil carinato, cocco (delapso) ad 19 mm. longo, epicarpio dissite verrucoso.

COSTA RICA: Vicinity of El Alto R. R. Station on road to Cartago, alt. 1550 m., *Allen 661* (TYPE); slope of Cerro Carpintera above La Unión de Tres Ríos, alt. 1350–1500 m., *Dodge & Goerger s. n.;* Alajuela: San Juanillo, alt. 1525 m., *A. Smith 2756;* same locality, alt. 1400 m., "Pacific tropical," *A. Smith 10008*. PANAMÁ: Chiriquí: Boqueli, alt. ca. 1300 m., *Davidson 865*.

In a previous paper, in Field Mus. Publ. Bot. **22**: 448. 1942, I provisionally referred this to *C. eluterioides* Lotsy. A careful study of all the species of this group so far known from Alabama to Costa Rica, undertaken on the basis of capsules and seeds, has eventually shown that Lotsy's species is not represented.

The forms in this affinity belong to Sect. *Eluteria* Griseb., and are characterized by a more or less densely lepidote foliage, and petaliferous ♀ flowers. Mueller-Arg., Schlechtendal, Baker and other authors have treated this section in a very unsatisfactory manner, which is understandable, considering that with few exceptions the species under it cannot be identified from characters other than those of the capsule and seed.

*Croton argyranthemus* Michx., extending from Georgia to Texas, suggests Sect. *Eluteria* Griseb. in some respects, and might ultimately prove to be an extreme depauperate form of this group. The species of Sect. *Eluteria* Griseb. which are all woody shrubs or trees, more or less densely lepidote and silvery, their ♀ flower petaliferous, styles usually several times dichotomous, and are natives of the region extending from Alabama to Panamá may be separated as follows:

Seed 11 mm. long, 6 mm. broad, or larger.

- Epicarp at maturity densely muricate with subwoody processes; seed 11 mm. long, 7 mm. broad, caruncle apical, conspicuous, testa ungrooved: Eastern Guatemala, Yucatán, Chiapas.............................*C. eluterioides* Lotsy.
- Epicarp at maturity with scattered subgranular warts; seed 14 mm. long, 9–10 mm. broad, caruncle frontal, inconspicuous, testa with 3–4 shallow grooves radiating downward from the caruncle: Panamá to Costa Rica, possibly northward to southern Guatemala.................................*C. pyriticus* Croizat.

Seed not over 10 mm. long, 5 mm. broad.

- Pedicel of fruit slender, scarcely or not at all woody, (1.5)–2 to 3.5 cm. long.
  - Leaves definitely elliptic, penninerved, with 8–14 or more pairs of subparallel very broadly spreading veins; seed 9–10 mm. long, 4–5 mm. broad; epicarp at maturity with few scattered warts: Vera Cruz and Chiapas, Mexico, to Venezuela, Ecuador, and the West Indies generally...........*C. nitens* Sw.
  - Leaves definitely ovate to lanceolate-ovate, with no more than 6–7 pairs of ascending veins; seed about 7 mm. long, 4–5 mm. broad; epicarp at maturity as in *C. nitens* Sw.; Central and Eastern Guatemala.*C. guatemalensis* Lotsy.
- Pedicel of fruit woody to subwoody, almost always stiff, less than 1.5(–2) cm. long.
  - Leaves elliptic, obtuse to short-acuminate, veins conspicuous, blade underneath markedly silvery to ashen; seed ellipsoid about 6 mm. long, 4.5 mm. broad: Alabama.................................*C. alabamensis* A. E. Smith.
  - Leaves lanceolate to lanceolate-elliptic, seldom ovate-cordate, veins weak or inconspicuous, blade underneath olivish to copper-colored, often glabrescent in age; seed ellipsoid 5–5.5 mm. long, about 4 mm. broad: Tamaulipas to British Honduras and Guatemala........*C. pseudochina* Schlecht. & Cham.
  - Leaves ovate to lanceolate-ovate, rounded to subcuneate at base, veins inconspicuous, blade underneath as in *C. pseudochina* Schlecht. & Cham.; seed scaraboid to sublenticular about 6 mm. long, 5–5.5 mm. broad: Chiapas?, Guerrero to Sonora............................*C. reflexifolius* H. B. K.

The specific limits in this group are not all evident in the same degree. Careful field studies and experimental cultivation are needed to elucidate the status of puzzling forms which gravitate around *C. pseudochina* Schlecht. & Cham., and *C. reflexifolius* H. B. K.

**Croton flavescens** Greenm. var. **Brandegeanus** var. nov.

A typo seminibus 4.5–5 mm. longis, neque 7–8 mm. longis recedit.

Mexico: Sonora: Between Mazatan and Matapé, 4 miles north of Macori, *Wiggins & Rollins 391.*

*Croton flavescens* Greenm. in Proc. Amer. Acad. 39: 81. 1903, and its forms constitute a complex, ranging from Michoacán, possibly farther south, to central Sonora. All these forms are more or less closely related to *C. fragilis* H. B. K., and *C. limnocharis* Croiz., but can be distinguished from these two species by the keel of the ovary and mature capsule, which is narrowed and prominent in *C. flavescens* Greenm., rounded off and quite

obscure in the other species. The entire group is most controversial, and should be subjected to experimental cultivation.

Here also belong: *Brandegee s. n.,* Culiacán, Sonora; *Rose, Painter & Rose 9413,* Guerreo, Iguala, and *Ferris & Mexia 5164,* Sinaloa, Labradas. The type-collection of *C. flavescens* Greenm. is *Pringle 8667,* Michoacán: Volcanic hills, Monte León Station, 5000 feet above sea-level.

**Croton glandulosus** L. var. **septentrionalis** Muell.-Arg. in DC. Prodr. 15(2): 686. 1866; Ferg. in Missouri Bot. Gard. Rept. 12: 51. *pl. 17.* 1901, *p.p. descr. emend.*
*Croton glandulosus* L. var. *angustifolius* Muell.-Arg. loc. cit.; Ferg. op. cit. 53. *pl. 16. f. 2. syn. nov.*

Semine ca. 3.25 mm. longo, 2.75–3 mm. lato (inde primo intuitu scaraboideo neque ellipsoideo), caruncula in speciminibus siccis subventrali (i. e., seminis a dorso spectata haud manifesta), arillo in semine maturo saepius brunneo badiove. Foliis saepius (saltem ad ramorum floriferorum radicem) acuminatis.

LECTOTYPUS: Arkansas, Little Rock, *Engelmann 6,* 1835 (in Herb. Missouri Bot. Gard.).

*Engelmann 6* is the lone specimen out of the six cited by Mueller-Arg. at publication which perpetuates the epithet *septentrionalis* in connection with the form currently identified as such in the literature. I cannot find the slightest differences by which to separate *Engelmann 6* from *Lindheimer 172,* Ferguson's presumed lectotype of *C. glandulosus* L. var. *angustifolius* Muell.-Arg.

**Croton glandulosus** L. var. **parviseminus** var. nov.

Semine ca. 3.25 mm. longo, 2.25 mm. lato (inde primo intuitu ellipsoideo neque scaraboideo), caruncula in speciminibus siccis subapicali (i. e., seminis a dorso spectata manifesta), arillo pallido maculis obscurioribus parcius notato.

TEXAS: *Lindheimer 691b* (Herb. Gray).

This variety, which better specimens and experimental cultivation may yet suggest to be better treated as a form, appears to be delicate, sparingly branched and subumbellate in habit. It does not seem to be frequent, for of it I have seen only three specimens, *Reverchon s. n.,* Buzzard Springs, Texas; *Sister Mary Clare s. n.,* Applewhite Rd. 18 miles South of San Antonio, Texas; *Sister Mary Clare 291,* Somerset Rd. 13 miles southwest of San Antonio, Texas. The type-collection was originally included by Mueller-Arg., in DC. Prodr. 15(2): 686. 1866, among the specimens cited as representing *C. glandulosus* L. var. *septentrionalis* Muell.-Arg.

**Croton glandulosus** L. var. **pubentissimus** var. nov.

Perennans, e loco natali a basi conferte ramosus subdumosus ca. 30 cm. altus, 50–60 cm. latus, cultus laxior at ramorum dispositione idem. Indumento subhispido copioso, foliorum lamina utrinque bene induta, pilis interdum adpressis habitu subsimplicibus. Perianthii lobis sub fructu quam capsula longioribus, semine ovoideo ca. 4 mm. longo, totidemque lato.

TEXAS: Kleberg Country, Padre Island, *Cory s. n.,* 1940.

This is a strong variety, quite unlike *C. glandulosus* L. var. *hirtus* (L'Hér.) Muell.-Arg., which it somewhat suggests in the abundant pubes-

cence. It certainly differs from *C. glandulosus* L. var. *Lindheimeri* Muell.-Arg., which is a more delicate plant, with short indumentum, well represented by the material of *Martindale* and *Parker*, collected at the Philadelphia Navy Yard, and erroneously identified by Ferguson (in Missouri Bot. Gard. Rept. 12: 52. 1901) as *C. glandulosus* L. var. *scordioides* (Lamck.) Muell.-Arg. *Croton glandulosus* L. var. *Simpsonii* Ferg. which may not differ from *C. arenicola* Small, has none of the characters of this new variety.

**Croton yavitensis** sp. nov.

Arbuscula ad 7 m. alta innovationibus grossius stellato-tomentosis pallide luteis ochraceisve. Foliis fere exacte ellipticis 6-15 cm. longis 2 6 cm. latis apice vix dilatatis sat abrupte acuminatis basi rotundatis subauriculatisque, supra costa puberula excepta glabris subnitidis, subtus pube laxa late stellata parcius pubescentibus, penninerviis ca. 8-jugis, margine remote obscureque dentato-serratis, petiolo ca. 5 cm. longo, stipulis subnullis. Floribus ♂ ignotis. Floribus ♀ sub fructu tantum visis sat mancis: perianthio 1 cm. minore lobis 5 integris triangularibus haud accrescentibus, petalis abortivis nigricantibus vix 1 mm. longis; capsula sub-3-dyma cylindrico-truncata ca. 1.5 mm. magna indumento pallide luteo fere eradiato scabrida, stylis taeniatis iterum partitis involutis, semine ellipsoideo ca. 1 cm. longo 0.8 cm. crasso, brunneo haud nitido, caruncula manifesta antica nempe crinito-fissa.

VENEZUELA: Amazonas: Yavita, *Williams 14029.*

This is a strongly marked species of uncertain affinities.

## Moacroton Croizat

**Moacroton** gen. nov.

Frutices vel arbores humiles e Cuba orientali, foliis coriaceis supra nitidis, subtus lepidibus plus minusve confertis adpressis tectis. Flore ♂ : perianthio in serie duplici 3–(5)-mero, petalis sepalis subsimilibus, pro ratione affinitatis valde diminuto: antheris 3–6 subsessilibus, scilicet in apice filamenti brevissimi potius pro glandula salutandi impositis, in anthesi subhorizontalibus, staminodiis nullis. Flore ♀ : perianthio 4 (5)-mero laciniis integris erectis vel suberectis, glandulis petalisve nullis: capsula coccorum dorso acutata: stylorum cruribus more proprio abbreviatis, integris vel 3–4-lobulatis: semine fere *Crotonis* L. in affinitate *C. reflexifolii* Kunthiani.

Genus optime a *Crotone* L. discedit: (1) Habitu proprio; (2) Natura androecii a genere Linneano omnino aliena, flore ♂ caeterum minimo; (c) Stylorum fabrica in *Crotone* L. haud obvia. Genus sistit relictum in regione Cubana formis peculiaribus celebrata. In systemate ad *Julocrotonem* Mart. inserendum.

Species typica: *Moacroton Leonis* Croiz.

This new genus keys out as follows:

A) ♂ flower petaliferous.
- a) Filaments filiform, at least elongate and cylindric; anthers introrse in anthesis, parallel with the center-line of the flower; stamens always more than 6....... ........ *Croton* L.
- b) Filaments very short, subglandular club-shaped; anthers almost horizontal in anthesis, perpendicular with the center-line of the flower; stamens 3–6........ ........ *Moacroton* Croiz.

B) ♂ flower apetalous.
a′) Stamens free.......................................*Lasiocroton* Griseb.
b′) Stamens in a column...............................*Leucocroton* Griseb.

This assemblage is remarkable on account of its genera differing mainly, if indeed not wholly, in the characters of the ♂ flower. Its species, however, can be separated only from the characters of the ♀ perianths. Great caution is therefore to be used, lest the ♂ flowers be overlooked as having slight significance.

**Moacroton Leonis** sp. nov. PL. I, FIGS. 5, 6.

Frutex videtur, innovationibus brunneo-furfuraceis. Foliis primo intuitu supra nitidis, glaberrimis atro-olivaceis valde coriaceis, margine bene revolutis, costa medio supra impressa, subtus prominente, nervis lateralibus nullis. Lamina longe elliptica, interdum vix ad medium parum dilatata, ad 6 cm. longa, 0.7 cm. lata vel minore, indumento supra nullo subtus lepidibus minimis valde sparsis, petiolo sat crasso ca. 0.5 cm. longo, glandulis ad basem limbi ipsissimam 2 pro more lente caute inquirendis, stipulis valde obsoletis. Inflorescentiis mihi adhuc obviis 1-sexualibus spicatis, ad 4–5 cm. longis, more proprio simul cum innovationibus prorumpentibus, quapropter aegre pro apicalibus lateralibusve salutandis, revera exquisite intercalaribus (vide Croizat in Bull. Torrey Club 70: 496–509. 1943), rachide crasso, floribus ♂ distantibus paucis in axilla squamulae valde ciliatae. Flore ♂ minimo quam 2 mm. minore pedicello gracili ca. 3 mm. longo: sepalis 4, petalis 3 subsimilibus pellucido-puncticulatis: androecio 3-mero antheris in apice filamenti clavati incrassati brevissimi. Flore ♀ in situ haud viso (adest fructus juvenilis tantum solutus, qui diligenter cum *M. trigonocarpi* (Griseb.) Croiz. comparatus, huic valde similis evadit): capsula 8 mm. longa, laevi, ca. 6 mm. lata, coccorum dorso carinato, hinc inde lepidibus sparsis ornata: stylo more generis brevissimo, vix 1 mm. longo, cruribus apice 1–3-lobulatis.

CUBA: Oriente: Region of Moa, tableland 400 m. high between the Río Cabanas and the Río Moa, growing on limonite, *Marie-Victorin & Clément 21735* (TYPE); same region, "charrascal" on serpentine at Playa de la Vaca, *Marie-Victorin & Clément 21774*.

It proves impossible under the present conditions to study the types of the species of Urban. However, the descriptions suggest that my new species is neither *M. Ekmanii* (Urb.) Croiz. nor *M. cristalensis* (Urb.) Croiz., which do not have narrowly elliptic leaves rounded or truncate at the tip. Nothing like my new species, likewise is to be found in Carabia's monographic study (Carib. Forest. 3: 114–135. 1942). The specific name honors Hermano León (Dr. Joseph Sylvestre Sauget y Barbier) of the Colegio de la Salle, Vedado, Havana, Cuba.

The inflorescence here described, if constant (which might well be the case), would constitute one more character further to differentiate *Moacroton* Croiz. from *Croton* L.

**Moacroton trigonocarpus** (Griseb.) comb. nov. PL. I, FIGS. 3, 4.

*Croton trigonocarpus* Wright ex Griseb. in Nachr. Gesell. Wiss. Gött. 1865, No. 7: 173. March 15th. 1865; Muell.-Arg. in DC. Prodr. 15(2): 576. 1866; Carab. in Carib. Forest. 3: 125. 1942.

**Moacroton Ekmanii** (Urb.) comb. nov.
*Croton Ekmanii* Urb. Symb. Antil. 9: 194. 1924; Carab. in Carib. Forest. 3: 125. 1942, *non* Leonard 1927.

**Moacroton cristalensis** (Urb.) comb. nov.
*Croton cristalensis* Urb. Symb. Antil. 9: 197. 1924; Carab. in Carib. Forest. 3: 125. 1942.

Urban appears to have overlooked *Croton trigonocarpus* Griseb., and it is not impossible that *Croton Ekmanii* Urb. and *C. cristalensis* Urb. may prove to be other than forms or varieties of Grisebach's much earlier species. I have seen authentic material of the latter, which patently differs from *M. Leonis* Croiz., but none of Urban's specimens. The transfers to *Moacroton* of all these entities is effected, consequently, as a matter of course, pending a final revision of the entire group.

## Argythamnia P. Browne

I see no reason to maintain *Ditaxis* Vahl ex Juss. as a genus distinct from *Argythamnia*. Accordingly, I treat the latter as **Argythamnia** P. Browne subg. **Ditaxis** (Vahl ex Juss.) comb. nov.

**Argythamnia coatepensis** (Brand.) comb. nov.
*Croton coatepensis* Brand. in Zoe 5: 249. 1908.

The holotype, *Purpus 2827* (in herb. Univ. Calif.) has a ♂ flower with the technical characters of *Argythamnia*, that is, the staminal column is single-whorled with no more than 5 stamens. In all other characters it is very difficult to separate this plant from the numerous polymorphic states of *Argythamnia guatemalensis* Muell.-Arg. (*A. tinctoria* Millsp. in Field Mus. Bot. 1: 303. 1896, syn. nov.) which ranges from Central America to eastern and western Mexico and Venezuela (*Potter 5145,* Guanta, roadside on the outskirts of the city, Herb. Gray).

**Argythamnia micrandra** sp. nov.

Fruticulus vix pedalis, radice videtur annua, pilis malphighiaceis sat longis ad caules indutus, parce ramosus. Foliis ellipticis vel obovato-ellipticis 2–3.5 cm. longis, 1–2 cm. latis apice breviter acuminatis basi longe cuneatis, ultra medium dentato-serratis subtrinerviis, aeque ac caulibus indutis, petiolo ca. 1 cm. longo, stipulis lanceolatis ad 3–4 mm. longis. Perianthio ♂ vix 2 mm. lato, sepalis 4, petalis setaceis minimis, columna staminali 9-andra vix 1 mm. alta. Perianthio ♀ ad 5–6 mm. sub fructu vix maturo lato, sepalis petalisque 5, petalis glandulosis minimis subnullisve, ovario in anthesi vix 0.75 mm. magno pilis erectis longe hispido, stylis minutis bipartitis.

Mexico: Guerrero: Coyuca, Cutzamala, *Hinton 6307* (Herb. Gray).

A very distinct, apparently weedy species. The 2-whorled minute staminal column, with about 9 stamens, is the technical character that places this entity under *Argythamnia* subg. *Ditaxis* (Vahl ex Juss.) Croiz.

## Alchornea Swartz

**Alchornea orinocensis** sp. nov.

Arbuscula ad 10 m. alta, innovationibus rachidibusque parcius puberulis glabratisve. Foliis penninerviis basi antice optime stipellatis, elliptico-ovatis

6-21 cm. longis 4–11 cm. latis apice breviter acuminatis basi rotundato-cuneatis, margine dentato-serratis serraturis apice incurvis glandulosisque ad 3 per cm., nervis ca. 7-jugis, trabeculis evidentibus, glandulis maculosis secus costam in axillis nervorum positis, petiolo sat gracili ca. 10 cm. longo, stipulis subnullis. Floribus ignotis. Fructu capsulari epicarpio tenui sublaevi vix granuloso, coccis delapsis ad 8 mm. longis, columella ca. 5 mm. longa, semine fere exacte ellipsoideo ad 6 mm. longo, 4.5 mm. crasso subcylindrico, ad chalazam fere truncato ad micropylem abrupte acuminato, arillo striato-rimoso brunneo subnitido.

VENEZUELA: Amazonas: Alto Orinoco, Tamatama, *Williams 15833* (TYPE); same locality, *Williams 15087*.

The strictly penninerved leaves, and the well-marked stipellae at the anterior face of the blade near the insertion of the petiole, as well as the cicatricose glands along the midrib are characteristic.

## Gitara Pax & Hoffmann

**Gitara panamensis sp. nov.**

Frutex vel arbuscula videtur, innovationibus hispidulis, cortice juvenili albicante rimoso, habitu toto rigido. Foliis obovato-lanceolatis 7–15 cm. longis, 2.5–6 cm. latis tenuiter chartaceis, glabrescentibus, penninerviis, trabeatis, nervis latius adscendentibus ca. 8-jugis, basi cuneatis vix vel haud truncatis, margine ad tertium inferum mediumve bene dentato-serratis (dentibus ad 7-8), apice abrupte sat longe caudatis, petiolo hispidulo ca. 0.5 cm. longo, stipulis membranaceo-scariosis basi incrassatis, triangulari-acuminatis, margine integris, adpressis ad 5 mm. longis. Inflorescentiis (videtur) lateralibus spicatis 1 4 cm. longis, mono-dioecis, floribus ♀ apicalibus terminalibusve. Perianthio ♂ simplici delicato ca. 3 mm. lato 2 mm. longo, ca. 5-lobo, staminibus ca. 30, 1.5 mm. longis, connectivo penicillato, staminodiis glandulisve nullis. Perianthio ♀ 6-mero lobis lanceolatis acuminatis integris anthesi peracta ca. 4–5 mm. lato, ovario maturescente ca. 5-6 mm. lato hispido, stylis 3 basi in columnan coalitis ca. 5–10 mm. longis subplumosis, glandulis nullis.

PANAMÁ: Hills between Pinogana and Yavisa, *Pittier 6543*, 1914.

*Gitara* Pax & Hoffm. is a segregate from *Tragia* L., which latter consists of a multitude of forms as yet scarcely understood. Its technical characters strongly suggest *Angostylis* Benth., to judge from the descriptions and illustrations I have so far seen, but it is otherwise easily mistaken for *Argythamnia* P. Browne, having been originally identified, distributed as representing the latter genus. I retain *Gitara* Pax & Hoffm. as a genus for the present.

*Gitara venezolana* Pax & Hoffm. has ecaudate leaves much narrowed at the tip, with truncate bases, the venation appearing as if markedly 3-nerved. In these characters, and, possibly, the smaller ♀ flower, Pax & Hoffmann's species does not agree with mine.

## Cunuria Baillon

**Cunuria (?) casiquiarensis sp. nov.**

Arbor ad 6 m. alta. Foliis firme coriaceis ellipticis 11–18 cm. longis, 7-10 cm. latis apice obtuse rotundatis, basi rotundato-cuneatis, margine inte-

gris. in sicco atrobrunneis, supra glaberrimis haud nitidis, subtus sparse minuteque puberulis, ad basem in lamina obscure cicatricoso-glandulosis, nervis patentibus ca. 10-jugis, petiolo validiusculo canaliculato 2–3 cm. longo stipulis subnullis. Inflorescentia ♂ ignota. Inflorescentia ♀ axillari rigida at 7–8 cm. longa indumento adpresso rufido tomentella. Perianthio ♀ 4–5-lobo, lobis vix 0.75 mm. longis triangularibus, petalis glandulisque nullis, pedicello sub fructu indurato, ad 1.5 cm. longo, ovario ovoideo ca. 1.5 mm. longo latoque trigono-costato pubescente, stylis sessilibus simplicibus 3 vix 0.5 mm. longis patentibus, columella coccis delapsis gracili ca. 5 mm. longa, apice abrupte incrassata.

VENEZUELA: Amazonas: Alto Casiquiare, Capihuara, *Williams 15690*.

The genera in this assemblage are ill defined, and it is difficult to make identifications unless one has complete material. *Cunuria* is suggested by the intangibles of habit, and the characters of the foliage, but the inflorescence is somewhat unconventional, when compared with that of *C. Spruceana* Baill., the standard-species. *Conceveiba* Kl. and *Conceveibastrum* (Muell.-Arg.) Pax & Hoffm. appear to ruled out of consideration by their foliage, and the manifest glands at the base of the ♀ perianth.

## Sebastiania Sprengel

**Sebastiania pusilla** sp. nov.

Fruticulus glaberrimus parte epigea, ut videtur, vix ultra palmari, ramis emortuis persistentibus intricato-ramosus. Foliis statu juvenili tantum visis carnosulis penninerviis pro more obovatis ca. 1 cm. longis totidemque latis margine incrassatis sat obscure denticulato-serratis omnino exaristatis, nervis 3–4-jugis, limbo toto eglanduloso apice obtuse acuminato vel retuso-truncato basi longius cuneato petiolo glanduloso canaliculato apice saepius laeviter papilloso ca. 1 cm. longo, stipulis papillosis triangulari-lanceolatis ad 0.5 cm. longis. Inflorescentiis terminalibus, basi flores 1–2 ♀ gerentibus nec ultra 2–2.5 cm. longis simplicibus spicatisque. Flore ♂ vix 1.25 mm. longo latoque in axilla squamulae basi glandulis 2 baculiformibus ornatae singulo: perianthio subintegro cupulari, staminibus subsessilibus 3. Flore ♀ vix 1.5 mm. longo, totidemque lato: perianthii lobis 3 late ovatis margine erosulis, glandulis obovoideis simplicibus subsimplicibusve cum lobis alternis, ovario in carinis corniculato, stylo fere ad basem 3-partito, cruribus vix papillosis simplicibus recurvis, semine ca. 1.75 mm. longo, 1.5 mm. lato, carunculato, pallide ochraceo-brunneo laevissime reticulato.

URUGUAY: Paysandú, Chapicuy, banks of the Río Uruguay, Sta. Sofia, *Rosengurtt B-4169*.

This is a remarkable species agreeing with none of the sections in the genus, and certain to become the type of a new one in the future. The persistent large petaloid appendages of the ♀ flower, the corniculate ovary, the subsessile stamens borne in a subentire perianth are characteristic.

## Sapium P. Browne

**Sapium contortum** sp. nov.

Arbuscula ad 60 cm. alta contorta, ramulis nigricantibus glaberrimis. Foliis subchartaceis ellipticis vel ovato-ellipticis, 3–8 cm. longis 1–3 cm. latis, basi latius rotundatis, apice abrupte acuminatis, margine obscure

serrato-denticulatis hinc inde glandulis majoribus auctis, nervis latius adscendentibus ca. 8–12-jugis, petiolo gracili ca. 1 cm. longo, glandulis petiolaribus plus minusve elongatis retroflexis, stipulis rotundatis margine profunde scariosis alabastra vegetativa apice inflexo tegentibus ca. 2 mm. longis latisque. Inflorescentiis ♂ tantum visis apicalibus ad 8 cm. longis, floribus glomerulatis 7–13, glomerulis basi glandulis elongatis 2–3 fultis, perianthio generis, vix 1.5–2 mm. longo.

VENEZUELA: Amazonas: Puerto Ayacucho, *Williams 15891.*

This species thrives on exposed rocky ledges, and is unusually low-growing for the genus. It might prove to be a local form of *S. Aubletianum* (Muell.-Arg.) Huber, the leaf of which, according to Huber's figure (in Bull. Herb. Boiss., sér. 2, 6: 363. *f. 23.* 1906) is also obscurely serrate and bears scattered large glands. However, the foliage of *S. Aubletianum* (Muell.-Arg.) Hub. should in no case be shorter than 10 cm., and the character of the leaf margin in this group is not primarily a specific one. I have no material at present representing *Sapium guaricense* Pitt., *S. naiguatense* Pitt., and *S. paucistamineum* Pitt., but find nothing in the descriptions to indicate that they may be dangerously close to my new species. To judge from fragments of *Spruce 511,* originally determined in the Paris herbarium as representing *S. prunifolium* Kl., it seems probable that Klotzsch's species is the same as *S. Aubletianum* (Muell.-Arg.) Huber.

## Euphorbia Linnaeus

**Euphorbia zerioides** Boiss. in DC. Prodr. **15**(2): 58. 1862.
*Euphorbia chiapensis* Brandeg. in Univ. Calif. Publ. Bot. **6**: 54. 1914. syn. nov.

As revealed by a comparison of *Purpus 6895*: Chiapas, Sierra de Tonala, and *Galeotti 3741,* the two species are absolutely synonymous.

**Euphorbia segoviensis** Boiss. in DC. Prodr. **15**(2): 58. 1862.
*Euphorbia Sloanei* L. C. Wheel. in Cact. Succ. Jour. **11**: 44. *fig.* 1939. syn. nov.

No difference exists between *Andrieux 105* and *Palmer 139* which may be said to be of significance, the two specimens being distinguished only by details of the pubescence, and the length of the petaloid appendages.

**Euphorbia radians** Benth. Pl. Hartweg. 8. 1839; Boiss. in DC. Prodr. **15**(2): 74. 1862.
*Euphorbia Stormiae* Croiz. in Rev. Sudamer. Bot. **6**: 13. 1939. syn. nov.

The differences that separate Bentham's species from my own are seemingly of little account. This species is treated by Boissier, op. cit. 71, 74, under Sect. *Poinsettia,* and by Wheeler, in Amer. Midl. Nat. 30: 482. 1943, under Subg. *Poinsettia.* A glance at material representing *E. lancifolia* Schlecht. and its allies might suggest that *E. radians* Benth. probably falls, on the contrary, under Boissier's Sect. *Dichilium,* that is, under Wheeler's Subg. *Agaloma.*

## Chamaesyce S. F. Gray emend. Croizat

**Chamaesyce arequipensis** sp. nov.

Multiceps humilis erecta tota patule hispida, internodiis 1–2 cm. longis vel ultra. Foliis carnosulis ovatis vel rotundato-ovatis 1–1.5 cm. longis, 1 cm. latis sub lente subeveniis 3-nervis, margine subintegris apice tantum

obscure lateque dentatis, petiolo 1–2 mm. longo, stipulis obscuris. Cyathiis in axillis solitariis, pedicello ad 4 mm. longo fultis late campanulatis ca. 2 mm. longis 1.3 mm. latis glandulis subhippocrepicis 4 conspicue appendiculatis appendice albicante inciso-dentata, laciniis ca. 3–4, ovario elongato-trigono hispidulo albicante, stylorum cruribus 3 fere ad medium partitis, basi in columnam brevissime coalitis, stigmatibus capitato-globosis; seminibus, videtur, ellipsoideis acuminatis, albicantibus, testa videtur sublaevi.

PERU: Arequipa: Prov. Camana, 4 km. from Caraveli on the road to Atico, alt. 1800–1900 m., *Metcalf 30341*. (U. S. Natl. Herb.).

The habit of this new species is reminiscent of that of *C. oranensis* Croiz. of Argentina, and *C. Barberiana* Croiz. of Paraguay.

**Chamaesyce rochaensis** sp. nov.

Annua vel perennans repens tota pilis albidis intricatis sat grosse lanulosa caulibus prostratis crassitie fili emporetici minoris vel gracilioribus internodiis 1–2.5 cm. longis, stipulis interpetiolaribus profunde partito-fissis. Foliis bene anisomeris ellipticis rotundatisve emaculatis cum petiolulo vix 1–2 mm. longo ad 1 cm. longis vel brevioribus margine (apice rotundato praesertim) sub lente grossius serratis fabrica haud coriacea. Cyathiis subsolitariis ob internodia abbreviata sub apices sat congestis campanulatis vix 1 mm. longis pedicello ca. 1–1.25 mm. longo, glandulis appendice petaloidea minima praeditis, capsula rotundato-trigona tota lanulosa ad 2 mm. longa lataque, semine carinato-ellipsoideo maturo pallide brunneo haud acuminato sublaevi, scilicet rugis subnullis lente acri caute inquirendis, ad 1.3 mm. longo, 0.65 mm. lato.

URUGUAY: Rocha, Fortaleza Sta. Theresa, "rara in uliginosis," *Rosengurtt B-2645* (TYPE); same locality, *Lombardo 2488*.

This is one of the forms commonly placed in the herbarium under *Euphorbia thymifolia*. It differs, however, from Indian material, such as *Metz (Hoehnacker) 67*, cited by Boissier in DC. Prodr. 15(2): 47. 1852, in its much larger capsules, its more robust habit, heavier pubescence and larger cyathia. It is not the same as *C. oranensis* Croiz. and *C. portucasadiana* Croiz., both of which are stouter plants with a different pubescence and other floral characters.

**Chamaesyce lutulenta** sp. nov.

Annua vel perennans radice recta subsimplici descendente quam parte epigea ut videtur majore insignis, cauliculis fili crassitie vel subgracilioribus ad 3–5, vix 2–4-ies partitis, totis, ut visis, nec ultra 5 cm. longis indumento lanoso albicante hispidulis. Foliis sat laxe lanosis suborbicularibus anisomeris ca. 0.5–0.7 cm. longis totidemque latis parte supera praesertim sub lente grosse denticulato-serratis emaculosis, petiolulo vix 1 mm. longo vel minore, stipulis interpetiolaribus late triangularibus denticulato-fissis. Cyathiis subsingulis purpurascentibus glabratis glabrisve arcte campanulatis vix ultra 1 mm. longis, glandulis rotundatis exappendiculatis (interdum margine albicanti-incrassatis), ovario rotundato-trigono glabro vix 1 mm. magno, semine ellipsoideo haud acutato nigricante sublaevi.

URUGUAY: Florida, Est. Timote, Estancia Sta. Clara del Dr. Gallinal, rare in moist localities, *Rosengurtt B-1654*.

This diminutive new species is strongly reminiscent on the whole of the North American *Chamaesyce Fendleri* (Torr. & Gray) Small, but is laxly hispid-lanose and has rounder dentate-serrate leaves.

## EXPLANATION OF PLATE I

FIG. 1. *Croton poecilanthus* Urb. Section through ♂ flower in bud, showing position of anthers in vernation characteristic of *Croton* L. FIG. 2. *Croton corylifolius* Lam. Section through ♂ flower at anthesis, showing nature and position of the stamens (only few left) characteristic of *Croton* L. FIG. 3. *Moacroton trigonocarpus* (Griseb.) Croiz., ♀ flower. FIG. 4. *Moacroton trigonocarpus* (Griseb.) Croiz. Styles and stigmas at anthesis seen from above. FIG. 5. *Moacroton Leonis* Croiz., ♂ flower at anthesis seen from above. FIG. 6. *Moacroton Leonis* Croiz. Stamen seen from the side (in slight foreshortening). FIG. 7. *Croton poecilanthus* Urb., ♀ flower; left, a style. FIG. 8. *Croton corylifolius* Lam., ♀ flower; right, a style.

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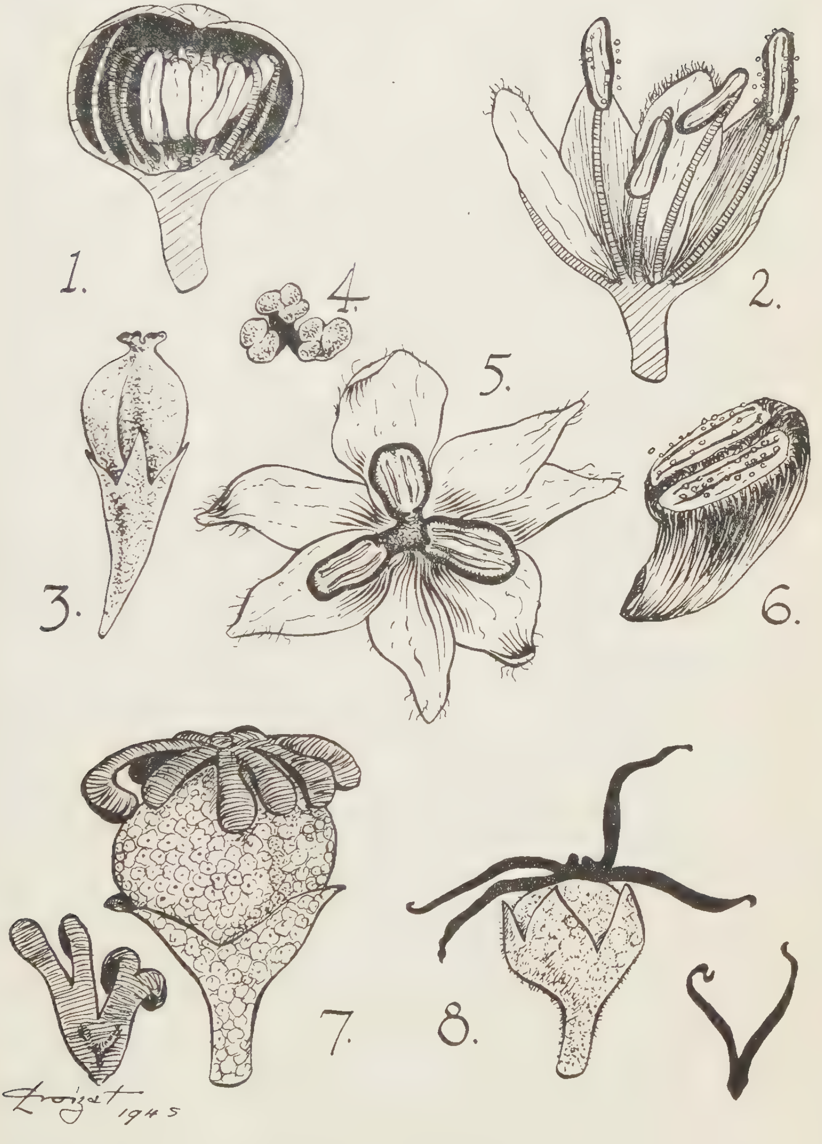


Euphorbiaceae from the Americas

# NOTES ON THE FLORA OF KUNG PING SHAN, KWANGTUNG

F. P. METCALF*

RECENT expeditions to Indo-China during the years 1936, 1939, and 1940, undertaken jointly by the Botanical Survey, Lingnan University, and the Arnold Arboretum, Harvard University, resulted in the collection of approximately 2800 numbers, each number with abundant duplicates. Of these, about three hundred and fifty were actually collected in Kwangtung Province. Kung Ping Shan is located in the extreme western part of Kwangtung Province, a few miles north of the Tonkin border.

This collection was made by Tsang Wai-Tak during July, August, and September, 1936, from two localities, Na Leung and Kung Ping Shan, Fang Cheng District, located on the north side of the river that separates Kwangtung from Tonkin, northeast of the town of Tung Hing, Kwangtung, and about equidistant between the sea-coast of Kwangtung at the Tonkin border and the Kwangsi boundary.

This region, so close to both the Tonkin (Indo-China) and the Kwangsi borders, would be expected to have a flora somewhat similar to both these regions, but an unusual aspect of the problem is the fact that the flora is apparently more closely related to that of Hainan than to those of central, eastern, or northern Kwangtung. Of the species recorded in this paper as new to Kwangtung, about ten were formerly known only from Hainan, eight were previously known from both Hainan and Tonkin, and ten were known only from Tonkin.

In this paper notes are given on 32 species that are here first reported from Kwangtung, representing the following genera: *Tacca, Hedyosmum, Ficus, Artocarpus, Boehmeria, Helicia, Talauma, Fissistigma, Desmodium, Walsura, Dichapetalum, Elaeocarpus, Flacourtia, Homalium, Clethra, Diospyros, Anodendron, Xylinabariopsis, Heterostemma, Tabernaemontana, Erycibe, Premna, Gomphostemma, Rhynchotechum, Hedyotis, Lasianthus, Nauclea, Paederia, Uncaria, Wendlandia,* and *Xanthophytum*. Of these 32 species, about 20 are actually new to China proper. The genera *Talauma* and *Xylinabariopsis* are here first recorded from Kwangtung and China. In addition, distributional or technical notes are included on species of *Itea, Prunus, Turpinia, Schizomussaenda, Urophyllum,* and *Pentaphragma*.

These notes constitute only a preliminary report, as the novelties, of which there are about ten, need further study. In addition, some special groups, such as the Euphorbiaceae, Lauraceae, Caprifoliaceae, and Thea-

*This paper was prepared by Dr. Metcalf on the basis of a Milton-Clark Fund Grant, Harvard University, to Dr. E. D. Merrill, Director of the Arnold Arboretum, for use in assisting him in working up the large accumulated collections of Chinese material at that institution. Other papers will follow.

ceae are being taken care of by specialists, while the species of *Ormosia* and *Sabia* are reported in Sargentia 3: 1–120. 1943. It is probable that in this small collection from Kwangtung at least twenty per cent of the species will represent new records for the province.

## TACCACEAE

**Tacca Esquirolii** (H. Lév.) Rehder, Jour. Arnold Arb. **17**: 64. 1936.

*Clerodendron Esquirolii* H. Lév. Rep. Sp. Nov. **11**: 298, 302. 1912; Fl. Kouy-Tchéou 439. 1915.

*Tacca Paxiana* Limpr. Pflanzenr. 92(IV. 42): 16. 1928; Pei, Mem. Sci. Soc. China **1**: 162. 1932.

KWANGTUNG: Kung Ping Shan, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26661,* Aug. 15–24, 1936. New to Kwangtung. Previously recorded from Kweichow, Yunnan, and Tonkin.

## CHLORANTHACEAE

**Hedyosmum orientale** Merr. & Chun, Sunyatsenia **3**: 36. 1940.

*Hedyosmum nutans* sensu Merr. Lingnan Sci. Jour. **5**: 59. 1928; Groff, Lingnan Sci. Jour. **11**: 87. 1930; *non* Swartz.

KWANGTUNG: Kung Ping Shan, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26692,* Aug. 15–24, 1936. The first record for Kwangtung and China proper. Formerly known only from Hainan.

## MORACEAE

**Ficus fistulosa** Reinw. in Blume, Bidjr. 470. 1825; King, Ann. Bot. Gard. Calcutta **1**: 114. *t. 150, 151.* 1888; Hook. f. Fl. Brit. Ind. **5**: 525. 1888.

KWANGTUNG: Kung Ping Shan, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26829,* Sept. 10–18, 1936. The first record for Kwangtung and China. Formerly known from India to Burma, Indo-China, and the Malay Archipelago.

**Ficus sikkimensis** Miquel, Ann. Mus. Lugd.-Bat. **3**: 225, 292. 1867; King, Ann. Bot. Gard. Calcutta **1**: 89. *t. 113.* 1888; Hook. f. Fl. Brit. Ind. **5**: 521. 1888.

KWANGTUNG: Kung Ping Shan, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26856,* Sept. 10–18, 1936. The first record for Kwangtung. Formerly known from Sikkim to the Khasia Hills in India, and Yunnan.

**Artocarpus tonkinensis** A. Chev. ex Gagnep. Bull. Soc. Bot. France **73**: 90. 1926; Merr. Lingnan Sci. Jour. **6**: 275. 1930, op. cit. **7**: 303. 1931.

KWANGTUNG: Kung Ping Shan, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26749,* Aug. 25–30, 1936. YUNNAN: Szemao, *Henry 13015.* The first record for Yunnan, and the first as a wild plant in Kwangtung. Formerly known from Tonkin and Hainan; cultivated in Kwangtung.

This species seems to be very close to *Artocarpus Petelotii* Gagnep., which was described by him at the same time as *A. tonkinensis.* Specimens from Indo-China, determined as representing *A. Petelotii,* have very similar but somewhat more pubescent leaves.

## URTICACEAE

**Boehmeria macrophylla** D. Don, Prodr. Fl. Nepal. 60. 1825; Wedd. in DC. Prodr. **16**(1): 209. 1869; Hook. f. Fl. Brit. Ind. **5**: 577. 1888.

KWANGTUNG: Kung Ping Shan, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26844,* Sept. 10–18, 1936. The first record for Kwangtung.

As usually interpreted, this species is reported from India, Indo-China, and Yunnan. The Yunnan and Indo-China material undoubtedly represents the same form as this Kwangtung specimen. There is, however, some question as to whether or not this represents the same species as that described by D. Don from Nepal; unfortunately we have seen no material from the classical locality.

## PROTEACEAE

**Helicia silvicola** W. W. Smith, Notes Bot. Gard. Edinb. **10:** 181. 1918.

KWANGTUNG: Kung Ping Shan, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26665,* Aug. 15–24, 1936.

This species was previously known only from the type locality, Szemao, Yunnan. Two specimens of *Henry 13075,* the type collection, are available for study; these are in flower. The Kwangtung specimen has mature fruits, of which a description follows:

Fruit ovoid to ellipsoid, 6–8 mm. long and 4–6 mm. wide, minutely and closely rufous-puberulent, with persistent style 15–18 mm. long, and short, rather stout pedicels 4–6 mm. long.

## MAGNOLIACEAE

**Talauma Candollii** Blume, Bidjr. 1: 9. 1825; Hook. Bot. Mag. **72:** *t. 4251.* 1846.

KWANGTUNG: Kung Ping Shan, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26656,* Aug. 15–24, 1936.

This represents the first record for the genus from China and from Kwangtung. The species ranges from Java, Sumatra, and Borneo to the Malay Peninsula, Siam, and Indo-China. The cited specimen closely matches a specimen collected by Sargent in Java and *Pierre 742* from Cambodia, Indo-China.

## ANNONACEAE

**Fissistigma polyanthum** (Wall.) Merr. Philip. Jour. Sci. **15:** 135. 1919; Merr. & Chun, Sunyatsenia **5:** 59. 1940.

*Uvaria polyantha* Wall. List No. 6467. 1832, *nomen nudum.*

*Melodorum polyanthum* Hook. f. & Thoms. Fl. Ind. 121. 1851; King, Ann. Bot. Gard. Calcutta **4:** 131. *t. 172A.* 1893.

KWANGTUNG: Na Leung and Kung Ping Shan, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26503, 26667,* July–August, 1936. The first record for this species from Kwangtung. Formerly known from Assam to northern Burma, Siam, Indo-China, Hainan, and Kwangsi.

## SAXIFRAGACEAE

**Itea amoena** Chun, Sunyatsenia **1:** 258. 1934, Ic. Pl. Sin. **5:** 19. *t. 219.* 1937.

KWANGTUNG: Na Leung and Kung Ping Shan, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26510, 26675,* July–August, 1936.

This represents the second collection for this province, the type being from Shap-Man-Tai Shan, a mountain on the Kwangtung-Kwangsi border. The species is to be expected in Tonkin, Indo-China, as the present collec-

tion was made only a few miles north of the border. Also known from Kwangsi (*Ching 8059*).

ROSACEAE

**Prunus Fordiana** Dunn, Jour. Bot. 45: 402. 1907; Dunn & Tutcher, Kew. Bull. Add. Ser. 10: 93. 1912; Groff, Lingnaam Agr. Rev. 2: 12. 1924; Merr. Lingnan Sci. Jour. 5: 87. 1930, in nota, sub *Prunus phaeosticta* (Hance) Maxim.

KWANGTUNG: Na Leung and Kung Ping Shan, along the Kwangtung-Tonkin border, *W. T. Tsang 26588, 26590, 26627, 26741,* August, 1936. HAINAN: Tai Un, *CCC 7742* (*McClure*); Paak Shek Shan; *LU 17444* (*Tsang*); Chim Shan, *Fung 20182;* Manning and Poting, *How 71520, 71653, 72723.*

This species was based on a specimen collected by Dunn's collector at Sanning, southern Kwangtung. Apparently this is its second collection in Kwangtung, though the species has been credited to Hainan. It has been confused with *Prunus phaeosticta* (Hance) Maxim., both having black-punctate leaves, but in *P. Fordiana* Dunn the apex is acuminate, not caudate-acuminate, the veins are obscure, and the fruit is larger, 8 mm. long, and ellipsoid rather than globose.

LEGUMINOSAE

**Desmodium longipes** Craib, Kew Bull. 1910: 20. 1910; Gagnep. in Lecomte, Fl. Gén. Indo-Chine 2: 570. 1920.

*Desmodium pulchellum* sensu Williams, Bull. Herb. Boiss. II. 5: 20. 1904, *non* Bak. (fide Schindler).

*Desmodium tonkinense* Schindler, Bot. Jahrb. 54: 53. 1917.

*Phyllodium longipes* Schindler, Rep. Sp. Nov. 20: 270. 1924.

KWANGTUNG: Na Leung and Kung Ping Shan, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26511, 26702,* July–August, 1936; also Sielung, Loting, *Y. Tsiang 1141,* Sept. 14, 1928.

This is the first record for this species from Kwangtung and China. Formerly known from Siam and from Cambodia, Laos, Cochinchina, Annam, and Tonkin, in Indo-China. The species has been confused with both *Desmodium pulchellum* (Linn.) Benth. (*Phyllodium pulchellum* Desv.) and *Desmodium elegans* (Lour.) Benth. (*Phyllodium elegans* Desv.), but it is easily distinguished from both of these by the much larger bracts (3.5 cm., not 1–1.5 cm.) and the larger leaves. In the size of the bracts it resembles *Desmodium Kurzii* Craib, a species of Siam, Burma, and China (Kwangsi), but it is readily separated from that species by the fact that the trifoliolate leaves have leaflets that are very variable in size; in *Desmodium longipes* Craib the terminal leaflet is very much larger than the two lateral leaflets, while in *D. Kurzii* Craib the three leaflets are all approximately of the same size.

MELIACEAE

**Walsura robusta** Roxb. Hort. Beng. 32. 1814, *nomen nudum,* Fl. Ind. ed. 2,2: 386. 1832; Pellegr. in Lecomte, Fl. Gén. Indo-Chine 1: 785. 1911; Merr. Lingnan Sci. Jour. 14: 20. 1935.

KWANGTUNG: Kung Ping Shan, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26690,* August 12–24, 1936. The first record for Kwangtung. Formerly known from India to Burma, Indo-China, Yunnan, and Hainan.

## DICHAPETALACEAE

**Dichapetalum hainanense** (Hance) Engl. in Engl. & Prantl, Nat. Pflanzenfam. 3(4): 348. 1896; Merr. Lingnan Sci. Jour. 5: 105. 1930.

*Chailletia hainanensis* Hance, Jour. Bot. 23: 322. 1885.

KWANGTUNG: Kung Ping Shan, Fang Cheng District, along Kwangtung-Tonkin border, *W. T. Tsang 26818,* Sept. 10–18, 1936.

This represents the first record of this species for Kwangtung and China proper; formerly known only from Hainan. The species is rather close to *Dichapetalum tonkinense* Engl., recorded from Hainan and from Tonkin, Indo-China. It can usually be separated from that species by the fact that the lower surfaces of the leaves are rather uniformly pubescent, the pubescence not being confined to the midrib and secondary nerves as in *D. tonkinense* Engl. The leaves also average slightly smaller.

## ELAEOCARPACEAE

**Elaeocarpus hainanensis** Oliver in Hook. Ic. Pl. 25: *t. 2462*. 1896; Merr. Lingnan Sci. Jour. 5: 123. 1928.

KWANGTUNG: Na Leung, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26636,* Aug. 1–10, 1936. Formerly known only from Hainan.

## STAPHYLEACEAE

**Turpinia glaberrima** Merr. var. **stenophylla** Merr. & Perry, Jour. Arnold Arb. 22: 552. 1941.

KWANGTUNG: Kung Ping Shan, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26739,* Aug. 25–30, 1936. This number is the type collection of the variety, which also occurs in Kwangsi. The species occurs in Kwangtung, Kwangsi, Hainan, and Indo-China.

## FLACOURTIACEAE

**Flacourtia Rukam** Zoll. & Mor. Syst. Verz. 33. 1854; King, Jour. As. Soc. Beng. 59(2): 117. 1890; Merr. Philip. Jour. Sci. 10: Bot. 329. 1915, op. cit. 29: 401. 1926, op. cit. 30: 411. 1926, Lingnan Sci. Jour. 5: 132. 1930.

KWANGTUNG: Kung Ping Shan, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26837,* Sept. 10–18, 1936. Indo-China to Malaysia, Polynesia, the Philippines, and Yunnan and Hainan in China. New to Kwangtung.

**Homalium Petelotii** Merr. Jour. Arnold Arb. 21: 377. 1940.

KWANGTUNG: Na Leung, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26568,* Aug. 1–10, 1936. Formerly known only from the type collection, *Pételot 5983,* from Tonkin, Indo-China. New to China and to Kwangtung.

## CLETHRACEAE

**Clethra annamensis** F. Dop, Bull. Soc. Bot. France 75: 732. 1928, et in Lecomte, Fl. Gén. Indo-Chine 3: 717. 1930.

KWANGTUNG: Kung Ping Shan, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26761,* Sept. 1–9, 1936. Formerly known only from Annam and Quang-tri, Indo-China. New to China and to Kwangtung.

## EBENACEAE

**Diospyros potingensis** Merr. & Chun, Sunyatsenia 5: 164. 1940.

KWANGTUNG: Kung Ping Shan, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26705,* Aug. 25–30, 1936.

The cited specimen apparently represents this species. It differs slightly

from the type in having proportionately longer and narrower leaves of a slightly different color, but the color difference may be due to the method of drying. If it is correctly named, this is the first record of the species for Kwangtung. Formerly known from Hainan and Hupeh.

## APOCYNACEAE

**Anodendron punctatum** Tsiang, Sunyatsenia 2: 129. 1934, op. cit. 3: 140. 1936.

KWANGTUNG: Kung Ping Shan, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26724,* Aug. 25–30, 1936. Formerly known only from three collections from Hainan. A species readily recognized by its punctate leaves.

**Xylinabariopsis napeensis** (Quintaret) comb. nov.

*Micrechites napeensis* Quintaret, Compt. Rend. Acad. Sci. 134: 438 (Seance du lundi 17 Février; received Harvard College Library, March 21). 1902.
*Xylinabaria Reynaudi* Jumelle, Rev. Cult. Colon. 11: 228. 1902.
*Ecdysanthera napeensis* Pierre, Rev. Cult. Colon. 11: 228. 1902.
*Parabarium napeense* Jumelle, in Spire, Caoutch. Indo-Chine 33. 1906.
*Xylinabariopsis Reynaudi* Pitard in Lecomte, Fl. Gén. Indo-Chine 3: 1261. 1933.

KWANGTUNG: Na Leung and Kung Ping Shan, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26523, 26643,* July–August, 1936.

It is difficult to understand why Pitard used the specific epithet *Reynaudi,* when both Pierre and Jumelle had already accepted the earlier epithet *napeense.* Formerly known from Annam, Laos, and Tonkin (Indo-China), and hence new to both China and Kwangtung.

## ASCLEPIADACEAE

**Heterostemma oblongifolium** Constantin in Lecomte, Fl. Gén. Indo-Chine 4: 120. 1912; Merr. Lingnan Sci. Jour. 5: 153. 1930.

KWANGTUNG: Kung Ping Shan, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26857,* Sept. 10–15, 1936. Formerly known only from Laos, Indo-China, and Hainan, and hence new to both the Chinese mainland and Kwangtung.

**Tabernaemontana bufalina** Lour. Fl. Cochinch. 117. 1790; Pitard in Lecomte, Fl. Gén. Indo-Chine 3: 1160. 1933; Merr. Trans. Am. Philos. Soc. II. 24(2): 312. 1935 (Comment. Lour. Fl. Cochinch.).

KWANGTUNG: Na Leung and Kung Ping Shan, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26547, 26654,* July–August, 1936. Previously known from Indo-China and Hainan, and hence new to the Chinese mainland and to Kwangtung.

## CONVOLVULACEAE

**Erycibe hainanensis** Merr. Philip. Jour. Sci. 21: 353. 1922, Lingnan Sci. Jour. 5: 153. 1930.

KWANGTUNG: Kung Ping Shan, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26640,* Aug. 15–24, 1936. Formerly known only from Hainan.

## VERBENACEAE

**Premna Maclurei** Merr. Lingnan Sci. Jour. 6: 330. 1930.

KWANGTUNG: Kung Ping Shan, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26657,* Aug. 15–24, 1936. Formerly known only from Hainan.

## LABIATAE

**Gomphostemma leptodon** Dunn, Notes Bot. Gard. Edinb. 8: 170. 1913, op. cit. 6: 190. 1915; T. Doan in Lecomte, Fl. Gén. Indo-Chine 4: 1036. 1936.

KWANGTUNG: Kung Ping Shan, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26790, 26825,* Sept., 1936. Formerly known only from Kwangsi (*Morse 257*) and from Tonkin, Indo-China; new to Kwangtung.

## GESNERIACEAE

**Rhynchotechum ellipticum** (Wall.) A. DC. in DC. Prodr. **9**: 285. 1845, *in nota;* C. B. Clarke, Commel. Cyrtandr. Bengal. *t. 91.* 1874 (*Rhyncotechum*), in DC. Monogr. Phan. 5: 198. 1893; Hook. f. Fl. Brit. Ind. **4**: 373. 1884; Merr. Lingnan Sci. Jour. 13: 71. 1934.

KWANGTUNG: Kung Ping Shan, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26854,* Sept. 10–18, 1936. Formerly known from India and Hainan; the first record for the Chinese mainland and Kwangtung.

## RUBIACEAE

**Hedyotis obliquinervis** Merr. Lingnan Sci. Jour. **14**: 56. 1935.

KWANGTUNG: Na Leung and Kung Ping Shan, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26518, 26644,* July–August, 1936. Previously known only from the type collection, *Lau 452,* from Fung Leng, Ngai District, Hainan. Additional collections of this species from Hainan are: *Lau 1265,* Tai Tin Shan, Changkiang District, *Liang 62029,* Yaichow, *Gressitt 960,* Ta Hau, and without definite locality, *Liang 64974* and *66230* and *Wang 32842.* The first record for the Chinese mainland and for Kwangtung.

**Lasianthus Koi** Merr. & Chun, Sunyatsenia **2**: 47. 1934.

KWANGTUNG: Na Leung and vicinity, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26558,* July 24–31, 1936. Previously known only from the type collection, *Ko 52243,* from Tingnan, Hainan. *Liang 54368* and *65280* and *Wang 35807,* from Hainan, without definite locality, also represent this species.

The original description was based on a flowering specimen. The following description of the fruit is based on *Tsang 26558.*

Fruit sessile, subglobose, black, subglabrous, 5 mm. long and about 4 mm. wide, capped by persistent calyx-lobes; lobes of calyx lanceolate, glabrous toward base, but covered with numerous, prominent, whitish, jointed hairs above the middle.

**Schizomussaenda dehiscens** (Craib) Li, Jour. Arnold Arb. **24**: 100. 1943.

*Mussaenda dehiscens* Craib, Kew Bull. **1916**: 263. 1916; Pitard in Lecomte, Fl. Gén. Indo-Chine 3: 174. *fig. 12, 2–3.* 1923; Chun, Sunyatsenia **1**: 306. 1934.

KWANGTUNG: Na Leung and Kung Ping Shan, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26513, 26576, 26668,* July–August, 1936.

While this note was originally prepared to record the species as *Mussaenda dehiscens* Craib as occurring in Kwangtung, Dr. Li's findings have been accepted. The species extends from Burma, Siam, and Indo-China to Yunnan, Kwangsi, and Kwangtung, having first been recorded from the latter province by Chun, without any citation of specimens, and by Li, who cites *Liang 69546* from Shih Wan Tai Shan. *Schizophragma macrosepalum* Hu (1930) and *Emmenopterys Rehderi* Metcalf (1932) are synonyms, according to Dr. Li, both of these genera belonging to the Saxifragaceae.

**Nauclea officinalis** Pierre ex Pitard in Lecomte, Fl. Gén. Indo-Chine 3: 26. 1922, *in syn.*; Merr. & Chun, Sunyatsenia **5**: 188. 1940.

*Sarcocephalus officinalis* Pierre ex Pitard, l. c.

KWANGTUNG: Kung Ping Shan, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26867,* Sept. 10–18, 1936. Formerly known from Indo-China and Hainan.

**Paederia verticillata** Blume, Bidjr. 968. 1825; Merr. Bibl. Enum. Born. Pl. 580. 1921, Enum. Philip. Fl. Pl. **3**: 570. 1923.

KWANGTUNG: Kung Ping Shan, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26751, 26787, 26874,* Aug.–Sept., 1936. A widespread species, known from the Malay Peninsula to Java and the Philippines. The first record for China and for Kwangtung.

**Uncaria scandens** (Sm.) Hutch. in Sargent, Pl. Wils. **3**: 406. 1916; Merr. Lingnan Sci. Jour. **11**: 59. 1930; Rehder, Jour. Arnold Arb. **16**: 319. 1935.

*Nauclea scandens* Sm. in Rees, Cyclop. **39**: no. 9. 1819.

*Uncaria pilosa* Roxb. Fl. Ind. ed. 2. **1**: 520. 1832; Hook. f. Fl. Brit. Ind. **3**: 32. 1880; Pitard in Lecomte, Fl. Gén. Indo-Chine **3**: 47. 1922.

KWANGTUNG: Kung Ping Shan, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26833,* Sept. 10–18, 1936. Also known from India and Indo-China, and from Yunnan, Kweichow, and Hainan, China. The first record for Kwangtung.

**Urophyllum chinense** Merr. & Chun, Sunyatsenia **2**: 19. 1934.

KWANGTUNG: Na Leung and Kung Ping Shan, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26512, 26770,* July and Sept., 1936.

This species is the only representative of this genus known from China proper, and it was formerly known only from the type collection, *Tso 23555,* from Sup Man Ta Shan, along the Kwangtung-Kwangsi border. One of the two collections cited above is in bud; the original description was based on a fruiting specimen only. A description of the young flowers is here added.

Buds ovoid, noticeably constricted at the base, glabrous; calyx saucer-shaped or broadly and shallowly campanulate, 5-lobed, the lobes broadly ovate-triangular, with glandular margins; pedicels filiform, about 6 mm. long, puberulent.

**Wendlandia tinctoria** DC. subsp. **orientalis** Cowan, Notes Bot. Gard. Edinb. **16**: 268. 1932, op. cit. **18**: 184. 1934.

*Wendlandia glabrata* auctt., in part, *non* DC.

KWANGTUNG: Na Leung, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26542,* July 24–31, 1936. Formerly known from India, Siam, Indo-China, and from Yunnan and Kwangsi in China; new to Kwangtung.

**Xanthophytum ferrugineum** (DC.) Merr. Mitt. Inst. Bot. Hamb. **7**: 270. 1937.

*Metabolos ferrugineus* DC. Prodr. **4**: 436. 1830.

*Xanthophytum Villarii* Vidal, Rev. Pl. Fasc. Filip. 150. 1886.

*Xanthophytum fruticulosum* sensu Merr. Philip. Jour. Sci. **4**: Bot. 328. 1909, Enum. Philip. Fl. Pl. **3**: 492. 1923, *non* Reinw.

KWANGTUNG: Kung Ping Shan, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 28721,* Aug. 25–30, 1936. KWANGSI: Shap Man Taai Shan, near Iu Shan village, Siangsze District, along the Kwangtung border, *W. T. Tsang 22306,* May 16, 1933. New records for both Kwangtung and Kwangsi, and also for China.

These specimens are associated with the Philippine species, which has only recently been segregated from the form of Java, Borneo, and Sumatra, on account of the differences in the inflorescences. The specimens seems to agree fairly well with the Philippine plant, but when flowering material

becomes available, some other disposition of them may prove to be desirable.

## CAMPANULACEAE

**Pentaphragma spicatum** Merr. Philip. Jour. Sci. 21: 511. 1922, Lingnan Sci. Jour. 5: 181. 1930.

KWANGTUNG: Kung Ping Shan, Fang Cheng District, along the Kwangtung-Tonkin border, *W. T. Tsang 26862,* Sept. 10–18, 1936.

This species was originally based on two specimens, one from Tung Sing, Kwangtung (*K. K. Tsoong 1907*), and the other from Ng Chi Leng, Hainan (*CCC 8075* [*McClure*]). This is apparently the second record of the species for Kwangtung.

ARNOLD ARBORETUM,
HARVARD UNIVERSITY.

# AN APPARATUS TO MAINTAIN A SURFACE FILM OF WATER FOR USE IN VEGETATIVE PROPAGATION

KARL A. GROSSENBACHER*

*With three text-figures*

VEGETATIVE propagation has long been of practical importance to nurserymen and others engaged in work with plants. The development of the theory of the hormone mechanism of root formation and availability of synthetic chemicals for treatment of cuttings has greatly increased the amount of work being done with vegetative propagation. Plant physiologists are interested in the phenomena of root formation as well as in the use of cuttings as a source of uniform experimental material. In the study of genetics of trees vegetative propagation becomes a valuable tool for the more accurate estimate of individual clones.

Doran (1) presents a summary of the work with trees and shrubs as well as an extensive bibliography. The standard practice has been to shade or cover propagating beds and to sprinkle the cuttings to prevent them from drying out during the period of root formation. Where leafless stems can be used, there is less evaporating surface and maintaining cuttings is a much simpler problem. For many species, however, it is necessary to use leafy cuttings, and their maintenance presents many problems. The water content must be kept up. They must have sufficient light to function properly and fungi must be controlled.

Raines (3) reports on a spray chamber technique for handling plant materials which promises to lead to new developments. Mitchell et al. (2) developed an out-of-door modification used to maintain cuttings in full sunlight. They found the most favorable environment for the propagation of slash pine (*Pinus caribaea* Morel.) to be "well drained sand . . . 75° – 90° F. . . . fine spray of water . . . on 5 minutes out of each 10-minute cycle for 10 to 12 hours each day." Others have pointed out that spray humidification in greenhouses has extended the limits of propagation of plants which are difficult to root (5).

Preliminary work in the greenhouses of the Harvard Biological Laboratories indicated that cuttings of several forest trees responded better in fuller exposure to sunlight than in the more conventional shaded beds. Tests were made with mechanical humidifiers as well as with intermittent spray. During the summer of 1944 an apparatus was developed and operated at the Harvard Forest. Taking advantage of full sunlight, out-of-

*This work has been financed by the Maria Moors Cabot Foundation for Botanical Research of Harvard University and was carried out at the Harvard Forest. The author wishes to thank C. T. Brown, Jr., S. H. Spurr, and P. R. Gast for their aid in the development and construction of this apparatus.

door propagating beds were equipped with a sprinkler system and an automatic control mechanism. This apparatus was designed to give maximum surface wetting with a minimum amount of water and was actually controlled by the evaporation of water from a surface film.

Cuttings of various forest trees were maintained in excellent condition. Satisfactory rooting was obtained with cuttings of red maple (*Acer rubrum*), sugar maple (*A. saccharum*), and paper birch (*Betula papyrifera*). No satisfactory rooting was obtained during the relatively short 6–8 week period with cuttings of hemlock (*Tsuga canadensis*), red pine (*Pinus resinosa*), white pine (*P. Strobus*), or white spruce (*Picea glauca*).

## APPARATUS

Propagation beds, as illustrated in *Fig. 1,* were built with gravel drainage and heating coils, allowing a 6-inch depth of builders' sand for planting cuttings. Sprinkler pipes were placed 10 ft. apart (every two beds) with flat misting nozzles (#.031F, Spray Engineering Co., Somerville, Mass.) every 3 ft. They are oscillated by a motor-driven crank, connected by rods to lever arms clamped directly on the pipes. The oscillating pipes are connected by loops of garden hose. The water supply (40 lb. pressure) is controlled by a single solenoid valve. An emergency by-pass with a normally open solenoid valve has been installed to supply constant spray in the event of any power failures.

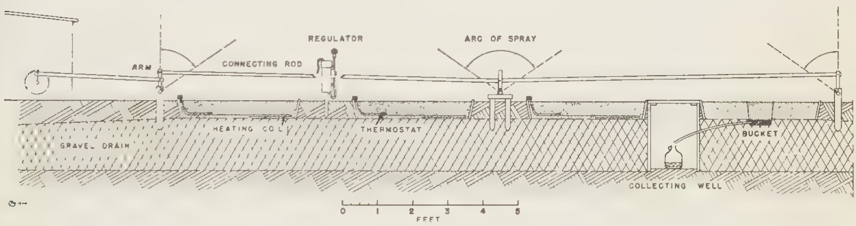


FIG. 1. Diagram of propagating beds.

The regulator, shown in *Fig. 2,* consists of a Livingston black bulb atmometer (B. E. Livingston, Riderwood, Md.) connected to a water-oil-mercury column. When a small amount of water is lost from the evaporating surface, the mercury moves up, making contact with the platinum wire activating the relay. This starts the oscillating motor and opens the solenoid valve. The regulator is so placed that water from the sprinklers falls on the evaporating surface, thereby replacing the water lost and opening the circuit. A distilled water reservoir is connected into the water column through a mercury safety valve to prevent undue water tension from developing in the regulator in case of mishap. By applying air pressure gently to the distilled water, the walls of the bulb can be conveniently flushed.

In order to reduce electrical action in the mercury-oil-platinum switch as

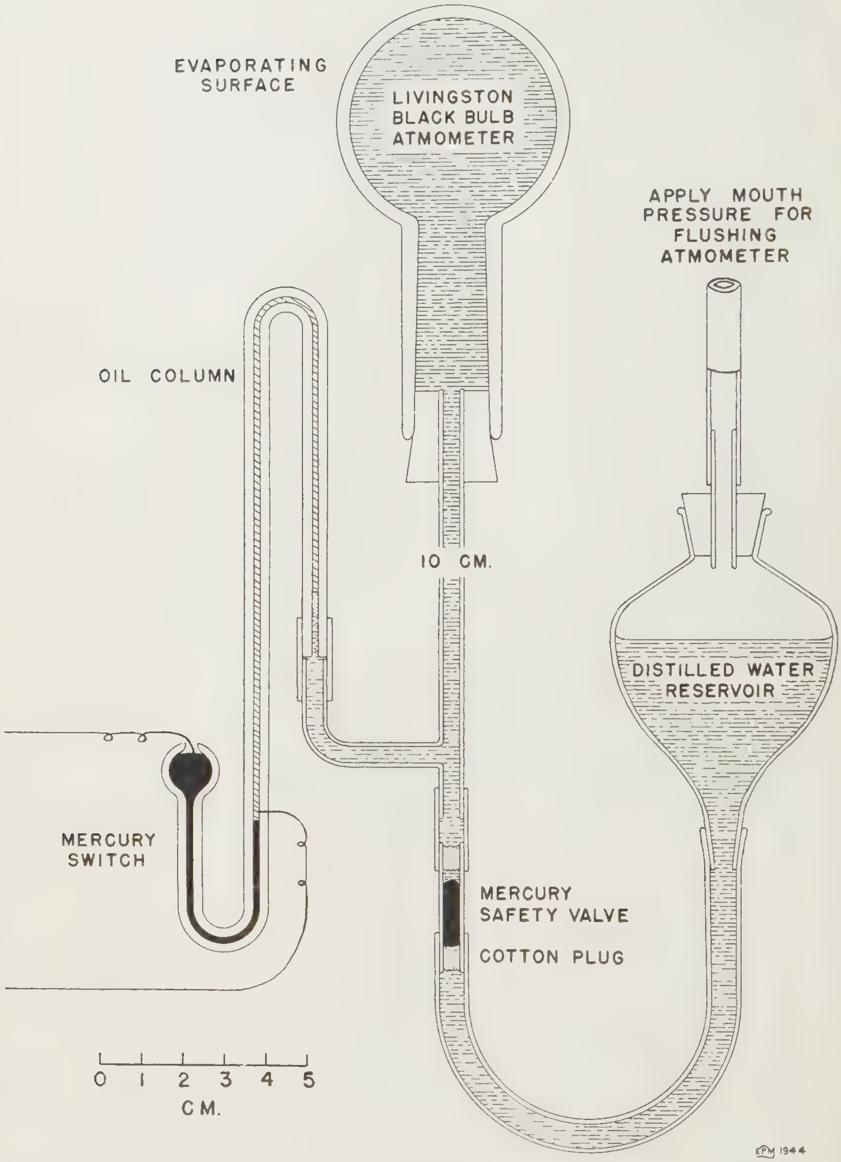


FIG. 2. Detail of regulator.

well as to assure uniformity of behavior, a two-coil, locking relay is used (Cenco #99740). The activator current is drawn directly from the 110-volt A.C. line with the load, relay coil, motor, and solenoid valve, in series. A single low amperage impulse (1/120 sec.) is enough to lock the relay in the on-position. A separate coil and circuit is used to open the relay, and the necessary impulse is drawn in a similar manner from the A.C. line. The circuit is closed by a contact-point on a wooden idler wheel, which is driven by the crank shaft of the oscillating mechanism. While the idler wheel makes one revolution in 30 seconds, the crank shaft makes 5, thereby giving five sweeps of the sprinklers per 30-second period. The momentum of the apparatus is sufficient to carry the contact points past the make-position, opening the off-circuit and clearing the relay for the next starting impulse. A small amount of chattering occurs if water from the sprinkler has not opened the starter circuit during the 30-second on-period. With the regulator placed midway between pipes and well within the range of several nozzles, this can only happen occasionally in dry windy weather.

This regulator mechanism has two fundamentally weak aspects. The evaporating surface and porous walls of the atmometer tend to accumulate deposits of materials dissolved in the spray water. Also, the electric current causes sludge to form at the junction of the oil and mercury. Though satisfactory contact is made when relatively large amounts of sludge have accumulated, the sludge can be expected eventually to cause trouble. The present apparatus has been operated for more than three months without interruption.

## PERFORMANCE

The oscillation of the sprinkler pipes can be adjusted to give satisfactory cover of the beds by changing the lever arms and connecting rods, etc. The two edge sprinkler pipes are set to supply a single bed with a short arc, thus giving a heavy watering to compensate for the effects of the wind. The center pipe swings through a larger arc, watering a bed on each side.

The regulator can be adjusted to give a wide range of performance. In order to maintain a film of surface water, the mercury in the outer arm of the mercury switch is put enough higher than the contact point nearly to balance the weight of water in the column supplying the bulb, thereby maintaining almost a free water surface on the bulb. Excess water drains off, and only a slight evaporation is necessary to start the sprinklers.

With this arrangement, the sprinklers turn on every 2 to 2½ minutes in bright dry weather, less frequently in cloudy weather, and only occasionally during the night. This means that the sprinklers are turned on about 240 times a day, or they run for about 2 hours out of the day, delivering 500 gallons over an area of about 500 sq. ft. (allowing for edge effects). This is equivalent to a rainfall of about 1.6 inches. However, a large portion of this water is actually lost by evaporation or blown away by the wind.

Records of sprinkler frequency were obtained with an independent circuit operating a chronograph. The drainage of water through the propagating bed was measured from three sampling buckets, as shown in *Fig. 1.*

Atmospheric temperature and humidity records were obtained in a standard weather shelter some 75 yards from the beds. Sample data for August 28, 1944, are presented in *Fig. 3*. The low temperature and high humidity of the preceding night kept the sprinkler off, and the drainage rate was therefore very low. As the day advanced, and the temperature rose and the humidity fell, the sprinkler came on more often, reaching by nine o'clock a fairly constant rate of 25 to 30 times per hour (highest recorded rate: 36 times per hour). The drainage for the 9 to 5 period reached the large amount of .326 cc per $cm^2$ per hour, being one of the highest drainage rates observed. As night came on and the humidity increased, the sprinkler

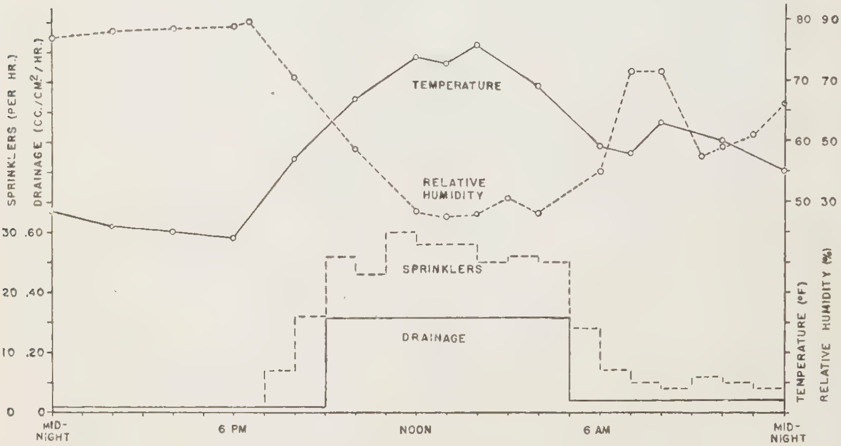


FIG. 3. Relation of sprinkler rate and drainage rate to relative humidity and temperature on August 28, 1944.

rate decreased. However, the humidity did not get as high as the preceding night, and the sprinkler rate leveled off at 4 to 6 times per hour. The unusual drop in humidity was reflected in the 9 P.M. to 10 P.M. sprinkler rate. Drainage for the overnight period was higher than for the previous night, as a result of the higher sprinkler rate.

## ADAPTATION TO OTHER USES

The combination of regulator and locking relay with A.C. circuits seems to open up a new field for the use of porous bulbs, cones, or soil points to regulate watering mechanisms. As in the present case, the regulator may be activated by the drying effects of the atmosphere; or, in soil or sand, by the tension of the water film. The latter arrangement would enable one to construct automatic irrigating devices which would respond to the water tension in the soil, rather than merely the drying effects of the atmosphere.

Possibly controls of this type can be of value in certain industrial processes.

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HARVARD FOREST,
PETERSHAM, MASS.

# THE GENERIC NAME PETALONEMA

J. P. M. BRENAN

THE GENERIC name *Petalonema* has the fortunately unusual distinction of having been used by various authors since the beginning of the present century for no fewer than four different genera of plants, belonging to as many families. The present investigation was undertaken in order to ascertain whether one of the four, *Petalonema* Gilg, a small African genus of Melastomataceae, was validly named or not.

The four homonymous genera are as follows:

1. *Petalonema* Correns in Flora 1889: 346. *t. 15, figs. 4–21.* July 1889 (Cyanophyceae—Scytonemataceae).
2. *Petalonema* Gilg in Engl. & Prantl, Nat. Pflanzenf. Nachtr. 264. 1897 (Melastomataceae).
3. *Petalonema* Schlechter in Repert. Sp. Nov. 13: 543. 1915 (Asclepiadaceae).
4. *Petalonema* A. Peter in Abh. Ges. Wiss. Göttingen, n. f. 13(2): 84. 1928 (Balsaminaceae).

## PETALONEMA Correns

The type of this genus is *Oscillatoria alata* Carm. ex Grev. Scottish Crypt. Fl. 4: *t. 222.* 1826. Upon this species Berkeley (Gleanings of British Algae 23. *t. 7, fig. 2.* 1833) based his new genus *Petalonema, P. alatum* being the only included species. According to the International Rules of Botanical Nomenclature (Art. 20, exceptions), the starting point of legitimate nomenclature of the Nostocaceae heterocysteae is Bornet and Flahault's Revision (1886-88); in this work (Ann. Sci. Nat. Bot. VII. 5: 110. 1887) *Petalonema* is included under *Scytonema* in synonymy and is therefore not validly published.

To ascertain the date of the first valid and legitimate publication of *Petalonema* is a matter of some difficulty. Geitler (in Engl. & Prantl, Nat. Pflanzenf. ed. 2. **1b**: 151. 1942) cites it as of "Berkeley . . . ex Kirchner in E.P. 1. Aufl. I. la (1898) 79"; this, however, is certainly not the earliest date. Wolle (Fresh-water Algae of the U. S. 267. 1887) took up *Petalonema* Berk. and described it. It will be noticed that Wolle's book and the relevant portion of Bornet and Flahault's Revision were published in the same year, and I have so far failed to find out which is the earlier. In view of the chronological doubt concerning Wolle's publication, it seems more satisfactory to accept that of Correns in Flora (1889). Correns, though he gives no formal diagnosis of *Petalonema,* on p. 346 clearly contrasts its characters with those of *Scytonema.* Mr. A. D. Cotton kindly undertook to give me his view on the validity of Corren's publication and, after discussion with Miss E. M. Wakefield, wrote that they were both of the opinion that the paragraphs in question "clearly describe *Petalonema* and validate its publication."

## PETALONEMA Schlechter

Realizing that *Petalonema* Schlechter was a later homonym of *Petalonema* Gilg, Quisumbing (in Philip. Jour. Sci. 41: 342. 1930) bestowed the new name *Schlechterianthus* on the former genus. It is desirable to note,

however, that *Schlechterianthus* is merely an orthographic variant of the previously published ficoidaceous genus *Schlechteranthus* Schwantes (in Monatsschr. Deutsch. Kakt.-Ges. 1: 16. 1929). Realizing this, Merrill (in Philip. Jour. Sci. 60: 33. 1936) renamed the Philippine *Schlechterianthus* as *Quisumbingia.*

### Petalonema A. Peter

Peter (l. c.) distinguished his genus from *Impatiens* L. by its possession of filiform appendages to the petals descending into the spur. G. M. Schulze, in a paper entitled "Zur Gattung *Petalonema* Peter," in Repert. Sp. Nov. **39**: 21–22. 1935, considered that this character was insufficient to justify generic separation and therefore reduced Peter's genus to *Impatiens.* Both Schulze (l. c.) and Mansfeld (on p. 36 of the same volume) noted that Peter's genus was a later homonym of that of Gilg; but neither botanist was evidently aware of the yet earlier algal genus. If *Petalonema* Peter is maintained as a distinct genus, it will have to be renamed.

### Petalonema Gilg

From the discussion under *Petalonema* Correns it is clear that *Petalonema* Gilg is a later homonym of the former genus. *Petalonema* Correns has been employed in several recent standard algological works on the continent, e. g. by Kirchner in Engl. & Prantl, Nat. Pflanzenf. **1a**: 79. 1900; by Geitler in Pascher, Süsswasserfl. Deutschl. Österr. u. d. Schweiz **12**: 261. 1925, in Rabenh. Kryptog. Fl. ed. 2. **14**: 788. 1932 (five species are dealt with here), and in Engl. & Prantl, Nat. Pflanzenf. ed. 2. **1b**: 151. 1942. The current use of *Petalonema* Correns and the fact that *Petalonema* Gilg is a small genus of restricted distribution make it evident that the latter is not a suitable candidate for conservation. It is therefore proposed to rename *Petalonema* Gilg as follows:

**Neopetalonema** nom. nov.

*Petalonema* Gilg in Engl. & Prantl, Nat. Pflanzenf. Nachtr. 264. 1897, et in Engl. Monogr. Afr. Pfl.-Fam. u. -Gatt. 2: 28. 1898; Engl. Pflanzenw. Afr. 3(2): 755. 1921; non Correns nec Schlechter nec A. Peter.

**Neopetalonema pulchrum** (Gilg) comb. nov.

*Petalonema pulchrum* Gilg, ll. cc.; Engl. l. c.

Gilg at first made *Petalonema* feminine, but later correctly changed its gender to neuter; the new generic name coined above will have the same gender (Int. Rules, Art. 72, examples).

A second species of *Petalonema, P. glanduligerum* Pellegr. in Bull. Mus. Nat. Hist. Nat. Paris **30**: 326. 1924, has been described from the French Congo. I have seen no material of this and am therefore at present unwilling to rename it.

In conclusion I must sincerely thank Mr. A. D. Cotton, Professor F. E. Fritsch, and Miss E. M. Wakefield for help with the algological part of this study.

Imperial Forestry Institute,
Oxford University,
England.

# LASTING PROPERTIES OF CUT FOLIAGE[1]

KARL A. GROSSENBACHER, STEPHEN H. SPURR, AND JAMES VLAMIS[2]

THE LENGTH of time that cut branches will retain their normal appearance and methods of increasing this period of time are of vital concern in modern warfare. Foliage is the principal raw material of military camouflage, and the way it is handled may well affect the life of the soldier or even the outcome of the battle. Simple guides to the use of cut foliage in camouflage, based upon extensive experimentation, have been prepared by the Harvard Camouflage Committee.[3] The present paper covers certain technical aspects of this research which may be of interest to the botanist and of value in peace time to those engaged in transplanting, in vegetative propagation, and in the use of fresh plant material.

## SPECIES SURVEY

That cut branches of different species of plants vary a great deal in their ability to retain their normal appearance is apparent to the most casual observer. Nevertheless, little work has been done to evaluate carefully the lasting properties of the common plants, and to ascertain how long the foliage of a particular plant will retain its normal appearance under various conditions. Tests carried out indoors or in the greenhouse are of little value in predicting the behavior of plants exposed to full sunlight, high temperatures, and drying winds.

To supply this information, several thousand tests have been carried out with plants of the northeastern United States at the Harvard Forest, Petersham, Mass., with European and Asiatic species at the Arnold Arboretum, Jamaica Plain, Mass., and with tropical foliage at the United States Plant Introduction Garden, Coconut Grove, Florida. No attempt was made to cover all the important species of any region, but an effort was made to secure a representative sampling of the most common plants. Most of the

[1]This paper is a partial report of the results of investigations carried out by the Harvard Camouflage Committee, a voluntary inter-departmental organization of Harvard University, comprised of staff members of the Maria Moors Cabot Foundation for Botanical Research, Harvard Forest, Biological Laboratories, and Arnold Arboretum. The coöperating institutions made available the necessary facilities and covered all expenditures of the Committee.

[2]The authors wish to acknowledge the coöperation of the United States Plant Introduction Garden at Coconut Grove, Florida, and that of camouflage officers in the Corps of Engineers and other branches of the United States Army. Among the members of the Harvard Camouflage Committee, I. W. Bailey, Ernest Ball, P. R. Gast, R. J. Lutz, E. D. Merrill (Chairman), K. V. Thimann, and R. H. Wetmore gave freely of their time and energy to those phases covered by the present report.

[3]Harvard Camouflage Committee. Using cut foliage for camouflage. 2 manuals, 17 pp. and 19 pp. Illus. Harvard Forest, Petersham, Mass. 1943.

tropical plants tested were lowland species, particularly those native to coastal regions.

Sprays of cut foliage of a uniform size (6 to 8 feet in Petersham and 3 to 5 feet elsewhere) were exposed on stakes or racks to full sunlight and all weather conditions. Careful notes of the condition of the plants were taken several times a day during the critical stages of drying, and daily at other times until the branches were completely withered. Each species was tested with at least two treatments: (1) base of branch suspended in air, and (2) base of branch immersed in water. Every treatment was replicated (five times in Petersham and three times elsewhere) and was repeated until reasonably consistent results were obtained.

The greatest difficulty encountered in these species surveys was that of developing a system of rating foliage condition that would give comparable results throughout the great variety of plants tested. Cut foliage reacts in many ways to drying out and death. Many plants brown; others, like *Viburnum*, blacken; still others, like *Eucalyptus* and some palms, whiten; and others, like pin cherry, develop autumn coloration. Some crisp, while others merely wilt. After initial trials, the following classification was set up and successfully used in dividing all plants into five broad classes of drying.

Class I. Normal. No evidence of wilting or injury.

Class II. Slight wilt. Essentially normal in appearance but evidence of drying such as (1) slight drooping of leaves, (2) marked wilt of young growing tips only, or (3) slight discoloration, usually on undersides of leaves only.

Class III. General wilt. Foliage wilted, but little or no (less than ten percent) crisping. Obviously abnormal in appearance, but foliage still essentially green and soft. Browning largely confined to undersides of leaves.

Class IV. Partially crisp. Marked crisping and discoloration of foliage, but more than fifty percent of leaves essentially green and soft.

Class V. Crisp. More than fifty percent of leaves crisp and discolored. Discoloration may consist of browning, blackening, whitening, autumn coloration, or merely marked fading.

During a given test, all foliage passed from Class I to Class V. At the time of each observation, a single rating was given for each species unless the variation was so great that single branches of the same species fell into different classes. The time necessary to pass through various classes was different for different plants. This difference might be used to explore certain physiological properties of species. The dividing line between Class II and III was taken as the limit of usefulness of plant material to be recommended for camouflage purposes. Selecting of any other point would result in a different ranking of species.

As a result of these surveys, it was possible to rate the relative lasting qualities of the different species, both with and without water (Tables 1 and 2). The values given for each plant cannot be considered as exact, since the lasting qualities of any plant are affected by many factors. The relative ranking of the different species, however, is reasonably accurate, and the values presented are a good indication of the number of days each species will last if exposed to full sunlight in the middle of the growing

TABLE 1.

Lasting of cut temperate foliage

| Days in sunlight without water | Species | Days in sunlight with water |
|---|---|---|
| 12 or more | Picea Abies (Norway spruce) | 14–21 |
| | Pinus resinosa (red pine) | 14–21 |
| | Pinus silvestris (Scotch pine) | 12–16 |
| | Pinus Strobus (white pine) | 10–14 |
| 6–12 | Picea glauca (white spruce) | 14–21 |
| | Juniperus communis (common juniper) | 14–21 |
| 2–6 | Tsuga canadensis (hemlock) | 4–10 |
| | Larix decidua (European larch) | 4–8 |
| | Larix Kaempferi (Japanese larch) | 4–8 |
| 1–2 | Malus pumila (apple) | 6–10 |
| | Ligustrum vulgare (common privet) | 6–10 |
| | Ligustrum ovalifolium (California privet) | 6–10 |
| | Vaccinium spp. (blueberry) | 4–8 |
| | Quercus velutina (black oak) | 3–6 |
| | Quercus borealis (red oak) | 3–6 |
| | Crataegus Oxyacantha (English hawthorn) | 2–4 |
| | Acer saccharum (sugar maple) | 2–3 |
| | Acer rubrum (red maple) | 2–3 |
| | Acer campestre (European maple) | 2–3 |
| ½–1 | Syringa vulgaris (lilac) | 6–10 |
| | Fagus sylvatica (European beech) | 5–8 |
| | Fagus grandifolia (American beech) | 3–6 |
| | Quercus robur (English oak) | 3–6 |
| | Quercus petraea (durmast oak) | 3–6 |
| | Quercus alba (white oak) | 2–4 |
| | Castanea dentata (chestnut) | 2–4 |
| | Tilia platyphyllos (large-leaved linden) | 2–4 |
| | Tilia cordata (small-leaved linden) | 2–4 |
| | Acer pseudoplatanus (sycamore maple) | 2–3 |
| ¼–½ | Prunus pennsylvanica (pin cherry) | 3–6 |
| | Acer pennsylvanicum (moosewood) | 2–3 |
| | Ginkgo biloba (ginkgo) | 2–3 |
| | Platanus acerifolia (London plane) | 1–3 |
| | Fraxinus excelsior (European ash) | 1–3 |
| | Prunus serotina (black cherry) | 1–2 |
| | Prunus Padus (European bird cherry) | 1–2 |
| | Alnus rugosa (smooth alder) | 1–2 |
| | Alnus glutinosa (black alder) | 1–2 |
| | Betula lutea (yellow birch) | 1–2 |
| | Betula papyrifera (paper birch) | 1–2 |
| | Betula populifolia (gray birch) | 1–2 |
| | Liriodendron tulipifera (tulip tree) | 1–2 |
| | Populus nigra (black poplar) | ½–2 |
| | Ulmus americana (American elm) | ½–1 |
| | Ulmus procera (English elm) | ½–1 |
| | Carya ovalis (small pignut hickory) | ½–1 |

TABLE 1. (*Continued*)

| Days in sunlight without water | Species | Days in sunlight with water |
|---|---|---|
| 0–¼ | Rhus typhina (staghorn sumac) | 3–6 |
| | Viburnum cassinoides (withe-rod) | ½–2 |
| | Populus grandidentata (big-toothed aspen) | ½–2 |
| | Populus tremuloides (trembling aspen) | 0–½ |
| | Fraxinus americana (white ash) | 0–½ |
| | Juglans cinerea (butternut) | 0–½ |
| | Robinia pseudoacacia (black locust) | 0–½ |
| | Salix nigra (black willow) | 0–½ |
| | Salix fragilis (crack willow) | 0–½ |
| | Salix pentandra (bay willow) | 0–½ |
| | Sambucus canadensis (elder) | 0–½ |
| | Ailanthus spp. | 0–½ |

season. These species surveys, covering more than one hundred different kinds of plants of the north temperate and tropic zones, reveal a number of phenomena, some commonplace and expected; others, rather surprising.

Tropical species reacted much the same as temperate ones. The range in number of days that plants would retain a normal appearance in sunlight is about the same, both in trials with water and in trials without. Plants from the tropics, as a group, seemed to respond to water about the same as temperate plants, a few profiting immensely, most lasting two or three times as long with water as without, and some incapable of taking up sufficient water to prolong the fresh appearance. The amount of water required to keep a cut branch alive is considerably less than the amount transpired by the same branch before being cut. A cut six-foot branch will ordinarily require up to a quart or more of water the first day, and decreasing quantities thereafter until the branch is dead. Coniferous foliage ordinarily requires less water than hardwood foliage, probably because of its better protection against water loss.

*Temperate Zone Foliage*

The most obvious generality that may be stated upon the basis of temperate zone tests is the common observation that conifers of all types retain their normal appearance far longer than hardwoods. The poorest conifer tested (larch) lasted longer than the best hardwood (apple).

The other obvious tendency is that plants of the same genus tend to have similar lasting qualities regardless of species, locality, or origin. Certain genera were particularly consistent in this regard, among them being *Larix, Ligustrum, Alnus, Betula, Ulmus,* and *Salix.* In all cases, variation within the genus was far less than variation between the genera.

Species of several genera were more or less consistent, but yet reacted differently in various degrees. In some genera, species characteristic of drier sites — plants whose structure was better adapted to retaining mois-

ture — apparently remained fresh the longest. Thus, red pine was somewhat better than Scotch pine, which, in turn, was definitely superior to white pine. A number of European species seemed to be somewhat better than their American counterparts, possibly because they had developed in a drier climate. Among these were European beech, European bird cherry, European ash, and European black poplar. This was not universally true, however, for the American maples lasted as well as the European hedge maple, and considerably longer than the European sycamore maple with its large thin leaves. The foliage of the latter, though, lasted longer than did the similar foliage of the American moosewood. When supplied with water, all five maples tested remained fresh for about the same period.

Among the oaks, the northern red oak was superior to the white oaks, both European and American, when tested in the absence of water. That the red oak group as a whole has greater lasting powers than the white oak group was substantiated by repeated tests not indicated in Table 1. With water supplied, little difference in reaction was noted.

Among the temperate species, the response to added water was relatively consistent. Practically all species benefited markedly from water except for a few plants which wilted and withered nearly as quickly with water as without. The response of staghorn sumac to a supply of water was exceptional. Cut sumac foliage would wilt the first day after being placed in water. Then, surprisingly enough, it would begin to recover. For several days thereafter, the leaflets would remain turgid, the plant being apparently normal except for a droop of the rachis. No other species tested showed this recovery from leaf-droop and wilt.

*Tropical Zone Foliage*

Tropical plants varied a great deal in their capacity to absorb water and in their lasting properties. Certain genera, such as *Casuarina*, *Ixora*, *Eugenia*, and *Eucalyptus*, lasted as much as five to fifteen times as long with water as without. Many others tested apparently were totally unable to utilize water (Table 2).

In one respect, tropical species behaved rather differently from temperate plants. Because of the large size and weight of many of the leaves, abnormal appearance was often first manifested by marked wilting of the petioles and consequent leaf droop, rather than by a change in the leaf itself. For instance, the leaves of the India rubber tree remained normal for two to four days after cutting, although petiole wilting rendered the plant abnormal in appearance in half that time. In the case of *Pandanus*, the leaves remained normal for six to twelve days, although severe stem droop occurred in half that period.

Among the palms, the coconut was among the several that lasted well. Others, however, whitened or drooped very soon after being cut. Foliage that was thick, heavy, shiny, and leathery, such as that of *Ficus*, *Rhizophora*, *Hernandia*, and *Barringtonia*, was moderately long-lived. Branches of these species were among those that drooped badly long before the leaves had begun to dry noticeably.

TABLE 2.

LASTING OF CUT TROPICAL FOLIAGE

| Days in sunlight without water | Species | Days in sunlight with water |
|---|---|---|
| 3–6 | Calophyllum inophyllum (palo maria) | 8–16 |
| | Aralia spp. | 8–16 |
| | Cocos nucifera (coconut)—entire tree | 8–16 |
| | Cocos nucifera (coconut)—separate fronds | 4–8 |
| | Caryota spp. (fishtail palms)—separate fronds | 4–8 |
| | Ptychosperma spp. (MacArthur palm)—separate fronds | 4–8 |
| | Pandanus tectorius (screw pine) | 3–6 |
| 1–3 | Casuarina equisetifolia (Australian pine) | 8–16 |
| | Ixora spp. | 8–12 |
| | Mangifera indica (mango) | 2–4 |
| | Pongamia pinnata | 2–4 |
| | Acacia spp. | 2–4 |
| | Musa sapientum (banana) | 1–3 |
| | Ficus bengalensis (banyan) | 1–3 |
| ½–1 | Eugenia Jambos (rose apple) | 8–16 |
| | Barringtonia asiatica | 2–4 |
| | Livistona spp. (fan palms)—separate fronds | 2–4 |
| | Hernandia peltata | 2–4 |
| | Melaleuca leucodendron | 2–4 |
| | Morinda citrifolia | 2–4 |
| | Ficus elastica (India rubber tree) | 1–2 |
| | Guettarda spp. | ½–1 |
| | Rhizophora Mangle (mangrove) | ½–1 |
| | Sterculia foetida | ½–1 |
| ¼–½ | Eucalyptus algeriensis | 4–8 |
| | Corypha elata (giant fan palm)—separate fronds | 1–2 |
| | Hevea brasiliensis (rubber tree) | 1–2 |
| | Aleurites moluccana (candle nut) | ½–1 |
| | Terminalia Catappa (Indian almond) | ½–1 |
| | Thespesia populnea | ½–1 |
| 0–¼ | Dodonaea viscosa | 1–2 |
| | Bambusa spp. (bamboo) | ½–1 |
| | Hibiscus tiliaceus | ¼–½ |
| | Styloma pacifica (palm)—separate fronds | ¼–½ |
| | Erythrina spp. | 0–¼ |

Few generalities can be drawn concerning the lasting of tropical foliage. This is due to the immense number of species in this zone and to the great difference in their size, structure, and growth habits. The fifty or sixty genera actually tested are sufficient only to tell us something of the range of lasting properties, of the reaction of some of the more important species, and of techniques useful in prolonging the lasting qualities of plants similar to those tested.

## SELECTION AND HANDLING OF CUT FOLIAGE

The length of time that foliage of a given species will last is affected by

(1) the size of the branch, (2) the part of the tree from which it is cut, (3) the time of day, and (4) the time of year the branch is cut. The importance of these factors was repeatedly demonstrated.

The larger the branch, the longer it will last. This applies both to branches with and without water. For instance, a twenty-foot red oak tree, cut at the base and guyed upright in a canvas-lined hollow filled with water, lasted about ten days, while few red oak branches lasted more than six days. Small sprigs of red oak foliage ordinarily drooped in two or three days. Similar results were obtained with hemlock in many repetitions. In Florida, entire coconut trees cut at the base and placed in water lasted about twice as long as separate fronds. The superior lasting qualities of entire trees and large branches as compared to small branches is probably due to the water supply available in the reservoir of the trunk and large limbs. This water is drawn upon by the foliage long after the water supplied is no longer taken up through the base of the cut stem.

That the part of the tree whence the branch came affects the lasting of the foliage is easily demonstrable, but the results obtained are difficult to explain. In the case of temperate zone species tested, foliage grown in full sunlight lasts longer when cut than foliage grown in partial shade. Sprout foliage of red oak, red maple, and yellow birch grown in full sunlight lasted longer than shade-grown branches of the same species. This phenomenon is to be expected, as the leaves of the former type are better protected against water loss, having thicker blades, thicker cuticle, and fewer stomata. Yet tests in Florida showed that the upper sun-grown foliage of *Pongamia, Sterculia,* and the India rubber tree definitely did not last as long as the low shade-grown branches from the same trees.

It has long been known that foliage cut in bright sunlight and supplied with water withers more quickly than foliage cut during cloudy periods or at night and similarly treated. This fact was confirmed by tests with six northeastern hardwoods. In all cases, foliage cut at 5 A.M. lasted longer than that cut at 11 A.M. The greatest difference occurred in red oak. Branches of this tree cut at 5 A.M. lasted six days; at 7 A.M., four days; and at 11 A.M., two days. This effect was observed only when branches were supplied with water, and can be satisfactorily explained by air lock, a phenomenon discussed below.

As would be expected, immature foliage is poorer in lasting quality than hardened mature foliage. It follows that branches cut in the spring will not last as long as those cut later in the season. Hardwood branches cut in the fall, however, are inferior in their lasting qualities to those cut in mid-summer. This is because cutting the branch is apt to hasten autumn coloration, as in cherry and sumac; and, more important, is apt to hasten leaf abscission (many species). The rapid drop of leaves in autumn-cut branches more than compensates for the low loss of water from the mature foliage in cool weather.

Experiments with the use of synthetic plant hormones (auxins) indicated that, in certain instances, these substances had beneficial effects on the

lasting qualities of cut foliage. It has been well established that auxin treatment retards the formation of the abscission layer, a principle utilized commercially by apple growers, and this retardation apparently may lengthen the life of branches cut in the fall. Also, auxin spray seems to maintain higher water content in leaves. It is further possible that auxin treatment influences metabolism, but it is difficult to determine whether the influence is direct or whether auxin influences metabolism by increasing water content by retarding abscission layer formation. The effect of the auxin treatment was observed in certain instances when branches were sprayed with water solutions (ca. 0.01%), but was more pronounced when applied in similar concentrations in combination with a wax emulsion spray (see below).

## SUPPLY OF WATER

Cut foliage can be kept alive for extended periods as long as its moisture content can be maintained. The problem of supplying water is the limiting factor in the preservation of cut foliage. Once water no longer reaches the leaves, wilting and crisping quickly occur.

### *Plugging*

Simply supplying water to the cut bases of branches does not necessarily keep the foliage fresh, as most plants have a wound reaction which plugs the cut stem and prevents water from reaching the leaves. The nature of this plugging is variable. It may be structural plugging, such as the development of tyloses and gum-like plugs in the vessels; it may be due to secretions such as latex and resin; it may be due to external agents such as bacteria and fungi; or it may be due to bubbles of gas in the vessels.

That plugging of vessels with tyloses and gum-like deposits is correlated with the cessation of water uptake in certain temperate plants was determined morphologically by Prof. R. H. Wetmore and Prof. I. W. Bailey, of Harvard University. In red oak, heavy tylosis formation takes place within a few days after cutting. In red maple, gum-like "amber" plugs develop in a similar period of time, mostly in the basal six inches. Both tyloses and "amber" plugs were formed very rapidly in willow.

In resinous plants, accumulations of exuded resin tend to seal off cut faces exposed to air. When the cut face is immediately placed in water, however, resin does not appear to interfere seriously with water uptake. Secretions of various tropical plants were much more troublesome. In particular, the latex of *Ficus, Hevea,* the mucilaginous sap of *Musa,* and similar secretions in representatives of other genera, tend to become suspended in the water, and in turn are drawn into vessels, where they form plugs at the first cross-wall.

It was further observed that films caused by bacterial accumulations occurred on the cut surfaces of stems containing no toxic substances such as tannin. These might well hinder water uptake, as would also extensive fungal activity.

In cut branches, air bubbles enter the vessels, forming "air locks," which presumably plug the stem and reduce water uptake. When the stem is

cut, transpiration immediately draws air up through the cut surface into the stem. If the stem is then placed in water, the air is confined within and will form bubbles at the first effective cross-wall. This explains why foliage cut before sunrise lasts longer than that cut at mid-day. In full sunlight, the heavy transpiration of foliage draws air into the stem as soon as the stem is cut. Consequently, regardless of how quickly the stem is placed in water, enough air has entered the stem to form an air lock. Early in the morning, or at any other time that the transpiration rate is low, little or no air enters the stem if the cut base is promptly immersed in water.

*Recutting*

It is possible to prevent the formation of an air lock by cutting the branch under water. When bent through a pail of water and severed from the tree by being cut under water, aspen and white ash branches took up two to three times as much water as controls cut in the air. This enables them to last longer.

Such a procedure, though sound, is not very practicable. Once a branch cut in air has been placed in water, however, it can be recut under water advantageously. This will remove any plugging in the basal portion of the stem, whether due to tyloses, secretions, bacteria, or air locks.

The efficacy of the recutting treatment depends upon the species involved. It materially lengthens the life of those in which plugging occurs largely at the base, and is naturally of little value when plugging occurs throughout the stem. In trials at Petersham, the life of cut branches of sugar maple, red maple, beech, yellow birch, and hemlock was materially lengthened by recutting under water. Red oak, chestnut, sumac, and pin cherry were not materially aided. The results obtainable by recutting under water are occasionally spectacular. In one instance, a sugar maple branch taken in midwinter was kept alive for three months. By a combination of recutting and the basal injection of water with pressures up to 15 lbs. per square inch, a full crop of leaves was grown and maintained for many weeks.

Apparently species with a long functional vessel length are not helped by recutting, as the air locks and other plugs are not confined to the base of the stem. By testing cut segments of stems with eight to fifteen pounds air pressure applied to one end and collecting the air bubbles under water at the other, it was possible to calculate the approximate functional length of open vessels. This length was several feet or more for red oak, Lombardy poplar, white ash, elm, cherry, and ailanthus; several inches for red maple, sugar maple, yellow birch, and black walnut. In conifers, the tracheids are so short that such measurements were not made. The longest functional vessel lengths observed were 35 feet for red oak and 20 feet for Lombardy poplar.

Recutting a cut stem in air proved better than no treatment but inferior to recutting under water. This is to be expected, as the structural basal plugs are removed by the treatment, but air locks are not prevented from being reformed.

The lasting properties of lactiferous plants can be materially lengthened

by washing the latex off the wound until it stops running, and also, to a lesser extent, by charring the base of the cut branch to coagulate the latex in the latex tubes, thereby preventing it from plugging the vessels.

*Purity of Water*

Water purity greatly influences the lasting of foliage, because impurities tend to clog up cut stems, thus reducing the rate of the water supply. This was demonstrated by trials at Petersham with sugar maple, red oak, beech, and hemlock. The reaction of sugar maple was typical. It lasted six days when supplied with water from a deep driven well; four days with clear, swift-flowing river water; three days with sphagnum swamp water; and two days with water from a stagnant pool. Water uptake for all species was closely correlated with lasting qualities.

In Florida, tests were carried out to see whether certain coastal species could be maintained with sea water. *Pongamia* and *Hernandia* were injured by salt water, and separate fronds of coconut quickly browned. Entire cut coconut trees and *Casuarina* were successfully maintained. In the case of coconut trees, the stem apparently filtered out the salt before the salt reached the foliage. Mangrove was successfully maintained in salt water as well as in fresh water only if the bases were cut under water and maintained there.

Extensive exploratory tests carried out by Dr. P. R. Gast and by the authors failed to reveal any chemical or combination of chemicals which when added to the water supply was much more effective in prolonging the fresh appearance of cut foliage than the use of water alone.

*Method of Supply*

The most obvious and most practicable means of supplying water to cut foliage is through cut bases. Water may also be made available to the plant in other ways.

Merely placing the cut bases in moist soil is sufficient to prolong the life of coniferous branches. A certain amount of water is supplied by capillary action, although this method is much inferior to standing the cut base in clean water. The value of placing coniferous stems in the ground was demonstrated by a number of tests, both indoors and outdoors, one of which is detailed in Table 3. Hardwoods require so much water that they are not helped by this treatment.

Water was also supplied through incisions in the stem, either made by a sharp blade or by an auger, and through the stubs of cut laterals. In the experiment summarized in Table 3, the amount of water taken up by hemlock foliage through cut bases and cut laterals was roughly proportional to the surface area of the sapwood exposed in the cuts. The most successful treatment, exclusive of wax treatments, was that in which water was supplied both through the cut base and a cut lateral.

Cut foliage can be maintained for long periods of time by placing the bases in sand and preventing the tops from drying out with an intermittent spray. In such a case, the rate of water loss is reduced to a very low level,

TABLE 3.

WATER SUPPLY AND WAX TREATMENT OF CUT HEMLOCK TREES[1]

| Treatment | Water content[2] (percent) | | | | Water uptake in 17 days (cc. per gr. total dry wt.) | Leaf fall (percent) | |
|---|---|---|---|---|---|---|---|
| Base in | 13 days | 27 | 40 | 80 | | 40 days | 80 |
| Air | 34 | 12 | 7 | 3 | | 100 | 100 |
| | 37 | 14 | 8 | 3 | | 100 | 100 |
| Soil | 49 | 36 | 24 | 3 | | 10 | 100 |
| | 49 | 39 | 19 | 11 | | 30 | 100 |
| Air—one lateral | 42 | 17 | 7 | 3 | .047 | 100 | 100 |
| with water | 42 | 19 | 8 | 3 | .051 | 100 | 100 |
| Air—two laterals | 44 | 31 | 14 | 3 | .057 + .064 | 96 | 100 |
| with water | 41 | 21 | 9 | 3 | .031 + .057 | 100 | 100 |
| Water | 54 | 55 | 40 | 3 | .854 | 0 | 100 |
| | 55 | 55 | 48 | 3 | .717 | 0 | 100 |
| Water—one lateral | 54 | 55 | 55 | 38 | .607 + .059 | 0 | 0 |
| with water | 56 | 56 | 56 | 8 | .738 + .076 | 0 | 70 |
| Air—sprayed | 48 | 31 | 18 | 3 | | 40 | 100 |
| with Dowax[3] | 41 | 34 | 9 | 3 | | 100 | 100 |
| Air—sprayed | 48 | 45 | 40 | 7 | | 0 | 95 |
| with wax solution[4] | 46 | 44 | 44 | 5 | | 0 | 30 |
| Water—sprayed | 54 | 54 | 49 | 4 | .582 | 0 | 95 |
| with Dowax | 53 | 53 | 48 | 5 | .464 | 0 | 95 |
| Water—sprayed | 54 | 56 | 57 | 40 | .259 | 0 | 3 |
| with wax solution | 55 | 55 | 56 | 43 | .393 | 0 | 6 |

[1]Tree six to eight feet tall placed in large room on December 16, 1942. Average daily range in temperature, 45 to 60° F. Average relative humidity, 50%.

[2]Original water content, average for all trees, 54%. All values below 35% represent fallen needles.

[3]One part Dowax to four parts water.

[4]One part paraffin to one part petrolatum to eight parts kerosene.

and enough water is taken up by the leaves to make up any deficit which may occur. The stems may be heavily plugged, but the development of new xylem will re-establish translocation after roots are formed. An automatic apparatus to accomplish this was constructed at the Harvard Forest, which maintained leafy cuttings of various species for the entire growing season.[4] Maintenance of this type is of no value in camouflage, but is a promising tool in the rooting of leafy cuttings.

## REDUCTION OF WATER LOSS

Inasmuch as loss of water is the primary cause of the death of cut foliage, it follows that any method which reduces water loss without otherwise affecting the plant will increase the period of normal appearance. The principal way of accomplishing this is to coat the foliage with a non-toxic substance, usually a wax or a mixture containing wax.

In the course of the present investigations, a great deal of exploratory work was carried on to investigate the possibilities of this type of treatment. A large number of substances were tried in many combinations under a variety of conditions. Although no material was found which could be highly recommended, enough was learned to reveal the limitations and possibilities of this means of reducing water loss.

A satisfactory coating must have two properties: it must form a thin pliable inconspicuous film capable of markedly reducing water loss, and it must be non-toxic to the living tissue of the plant. Unfortunately, these two characteristics rarely occur together.

The effectiveness of a film in reducing water loss may be determined by observations of the lasting quality of branches, by measuring water uptake, by measuring changes in total plant weight, and by determining moisture content. Observation suffices only to distinguish living foliage from dying and dead foliage. Water uptake may be used as an index of water loss, especially for longer time periods. Thus, in Table 3, the hemlocks sprayed with wax solution required less water and lasted better than trees sprayed with Dowax. Moisture content, whether determined directly from samples, or indirectly by measuring the loss of weight of a drying cut branch, is an index of the ability of the coating to reduce water loss. This, too, is illustrated in Table 3.

Death of living tissue is indicated by color and structural changes which markedly alter the normal appearance of the plant. Any substance causing the death of tissue, therefore, is undesirable as a protective coating. Toxicity is governed by a large number of factors, such as temperature, method of application, and chemical composition of the coating. Chemicals toxic to foliage even in a low concentration are not necessarily toxic in combination, as in the case of ammonium hydroxide in Emulsion B, Table 4. Most of the coatings tried in the present investigation proved to be toxic in one way or another. Conifers are much more resistant to

[4]Grossenbacher, Karl A. An apparatus to maintain a surface film of water for use in vegetative propagation. Jour. Arnold Arb. 26: 206–211. 1945.

TABLE 4.

TESTS IN FULL SUNLIGHT WITH WAX EMULSION DIPS ON BRANCHES SUPPLIED WITH WATER

| Species | Control | Dowax[1] | Emulsion A[2] | Emulsion B[3] |
|---|---|---|---|---|
| | Average number of days before reaching Class III | | | |
| Red oak | 4 | 6 | 8 | 5 |
| White oak | 3 | 5 | 8 | 6 |
| Chestnut | 4 | 2 | 6 | 5 |
| Beech | 4 | 3 | 6 | 3 |
| Paper birch | 2 | $1\frac{1}{2}$ | 3 | 2 |
| Elm | 1 | 1 | 1 | 1 |
| Aspen | 0 | 0 | 1 | 0 |

[1]One part Dowax to three parts water.

[2]Paraffin, 7.7g.; Duponol WS, 2.3g.; linseed oil, 3.5ml.; glue, 1.0g.; water, 200ml.

[3]Candellila wax, 5.0g.; Neomerpin, 1.0g.; Ammonium hydroxide, 4.0g.; kerosene, 4.2ml.; water, 6.3ml. Concentrate diluted, one part to three parts water.

toxic effects than hardwoods. The development of a non-toxic coating is the principal difficulty in solving the problem of how effectively to reduce water loss and maintain living foliage.[5]

Coatings fall into two general classes: solutions and emulsions. Solutions of various waxes in organic solvents are highly effective in preventing water loss. Most of the solvents, however, are highly toxic to living tissue. The most promising solution used was a mixture of one part paraffin and one part petrolatum in eight parts of kerosene. This proved extremely effective in preventing water loss (Table 3), and of low toxicity when sprayed on foliage at such a temperature that the film solidified as soon as it was formed. It was very toxic, however, when used at higher temperatures, or when applied as a dip. In these cases, greater penetration occurred, and penetration of any coating was found to be conducive to toxicity.

Emulsions have a basic advantage over solutions in that they may be applied in a non-toxic medium — water. Among the emulsions tested, a commercial preparation known as Dowax proved reasonably efficient in prolonging the life of conifers but not of many hardwoods (Tables 3 and 4). It was toxic in varying degrees with several of the plants tried. Experiments made by Dr. P. R. Gast in Florida indicated that its use materially prolonged the life of fronds of the cabbage palm (*Sabal palmetto*) and the leafy foliage of blackjack oak (*Quercus marilandica*). Auxin treatment, as mentioned above, apparently lengthened the life of cut foliage somewhat when used with Dowax on branches supplied with water. This

[5]Comar, C. L., and Barr, C. G. Evaluation of foliage injury and water loss in connection with use of wax and oil emulsions. Plant Physiology **19**: 90–104. 1944.

emulsion was developed by E. J. Miller[6] and contains a wax, an ammonium salt of a drying acid, and a colloidal earth.[7]

Emulsion A (Table 4, footnote 2) was the most promising developed in the present investigations. It is a non-ammonical mixture but inconvenient in that it cannot be prepared in a concentrated form. For hardwood foliage it was of low toxicity and highly effective in reducing water loss. This emulsion was developed by Dr. Ernest Ball, of Harvard University, who participated actively in the development of satisfactory coatings.

Emulsion B (Table 4, footnote 3), an ammonical mixture which could be prepared in a concentrated form, was also effective in reducing water loss. The emulsifiers used in this and other emulsions, as well as certain other chemicals, were provided by the E. I. Dupont de Nemours Company.

All the coatings mentioned above are effective only when water is supplied to the treated foliage. Without water, improvement was noted only in certain cases. The lasting of conifers could usually be lengthened somewhat. Emulsions A and B also helped certain hardwoods, such as red oak and paper birch. This limited effect in the absence of water is to be expected, inasmuch as a protective coating is of value only in reducing water loss to a rate comparable with that of water uptake, thus keeping the plant tissue alive. If water is not supplied, a protective coating can lengthen life only a short time by retarding the loss of water already present in the plant.

## SUMMARY

Extensive investigations were carried out to determine how long cut foliage of different species will retain its normal appearance under various conditions, and how the life of cut foliage can be maintained.

More than one hundred representative species of the northeastern United States, western Europe, Asia, and the tropics were tested and classified as to their lasting qualities, both with and without a supply of water.

Conifers proved to be greatly superior to hardwoods in their lasting qualities. Plants of the same genus tended to have similar lasting qualities regardless of their geographic origin.

The range in lasting qualities of tropical species was much the same as that of temperate plants. In the tropics, however, because of the large size and weight of many of the leaves, abnormal appearance of drying foliage often was first manifested by marked wilting of the petioles and consequent leaf drooping, rather than by a change in the leaf itself.

A number of factors involving the selection and handling of cut foliage affect their lasting qualities. The larger the branch, the longer it will last. Foliage grown in full sunlight generally lasts longer than shade-grown foliage, although upper sun-grown branches of certain tropical species were found to be inferior to lower limbs grown in the shade. Mature foliage

[6]Miller, E. J., Meilson, J. A., and Bandemer, Selma L. Wax emulsions for spraying nursery stock and other plant materials. Michigan Agr. Exp. Sta. Spec. Bull. 282. 39 pp. 1937.

[7]U. S. Patent no. 2,013,063.

lasts better than immature, but late season foliage does not last as well because of abscission layer formation. In certain instances, auxin treatment has beneficial effects on the lasting qualities of cut foliage, both in retarding abscission and in maintaining water content.

Supplying water generally increases the life of foliage two to four times. Water ceases to reach the leaves, however, in a few days, due to plugging of the stem. This plugging may be due to tyloses or gum-like deposits in the vessels, to secretions, such as latex or resin, to bacteria or fungi, or to air locks—bubbles of air in the vessels. By cutting foliage when the transpiration rate is low (during rains, early in the morning, etc.), plugging from initial air locks can be minimized.

In plants with functionally short vessels, where plugging occurs mainly in the basal portion of the stem, recutting the stem under water will remove the plug and materially increase the life of the foliage.

Cut foliage lasts best in pure water, as solid particles clog the vessels and chemical impurities may injure the living tissues. Salt water (sea water), however, successfully maintained cut branches of a few tropical coastal plants.

No chemical or combination of chemicals was found which would increase the lasting of cut foliage.

Water can be successfully applied to cut branches through the base, through cut laterals, and through stem incisions.

The reduction of water loss by means of a non-toxic coating will materially increase the life of cut foliage. Despite extensive experiments, no highly successful coating was developed. Several coatings however, were satisfactory under certain conditions. Among these coatings were one solution of paraffin and petrolatum and two emulsions: a non-ammonical one with paraffin, and an ammonical one with candellila wax. Waxy coatings are particularly effective when the treated foliage is supplied with water. The most satisfactory coatings approximately double the life of many species.

HARVARD FOREST,
PETERSHAM, MASS.